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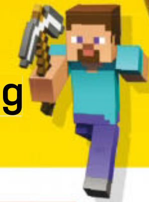

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The Ambury, Bath BA1 1UA
Tel 01225 442 244 **Fax** 01225 732 275
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Printed in the UK by: William Gibbons & Sons Ltd on behalf of Future
Distributed by: Seymour Distribution Ltd, 2 East Poultry Avenue, London EC1A 9PT, Tel: 0207 429 4000
Overseas distribution by: Seymour International

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Alan Dexter, Editor

THE INCREDIBLE SHRINKING RAY?

THERE'S AN ASSUMPTION in this industry that tech will continue to get smaller. To get faster. To get cheaper. This phenomena even has its own 'law' – Moore's Law. It isn't really a law, but that's beside the point. It simply shows how ingrained the idea is. It has underpinned the industry for 50 years, and, despite several potential blocks, it has continued to struggle on, defining the complexity of our chips.

The problem is, this concept is beginning to come unstuck. On many levels. Not only is hitting each shrink getting harder and harder, but the payoffs are getting less and less impressive. And getting silicon super small is getting more and more expensive to achieve – kitting out a fab with the latest slightly smaller manufacturing process can cost twice that of the previous size, and we're already talking tens of billions to get such a plant up and running.

Intel's new sixth-gen processors are a case in point. Skylake uses the latest 14nm production process, but the improvements aren't obvious. Although power consumption is notably lower, actual performance isn't a paradigm shift. Even here, it hasn't been easy, with the mighty Intel taking a long time to get it right. Skylake's predecessor, Broadwell, was so delayed it was only released a month before Skylake landed on desktops. Meanwhile, Nvidia and AMD have seen delays on their preferred production process – with both expected to be rocking GPUs based on the 20nm process by now, but neither is.

So simply expecting to shrink your transistors down isn't enough. More and more it's about what you do with them that counts. And thinking outside of the traditional two-dimensional box appears to yield the biggest gains. The likes of 3D-stacked memory has meant that Samsung could use a more mature production process to produce cutting-edge SSDs. And indeed, AMD's latest GPUs look at memory in a different way to weave its (somewhat limited) magic with the Fury and Fury X cards.

There will still be advancements, of course, but it feels that thinking innovatively is going to produce more interesting results than just shrinking everything down.

Alan Dexter, Editor

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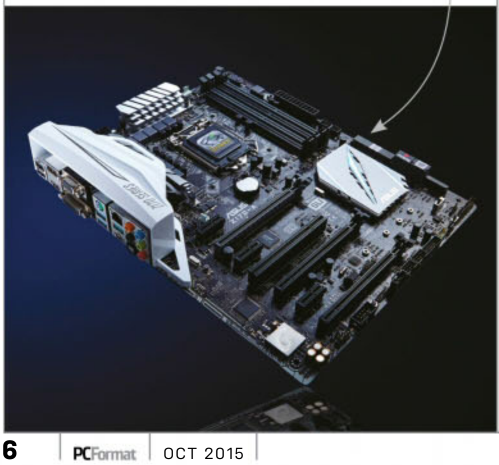

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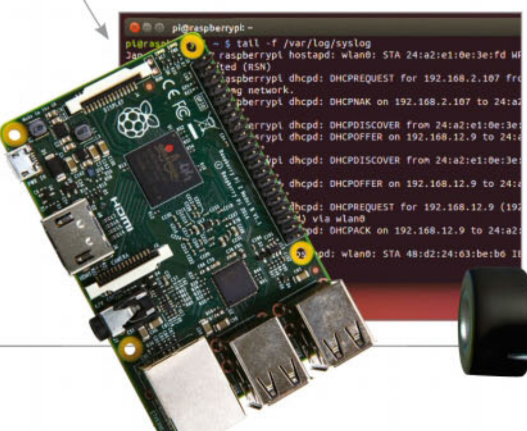

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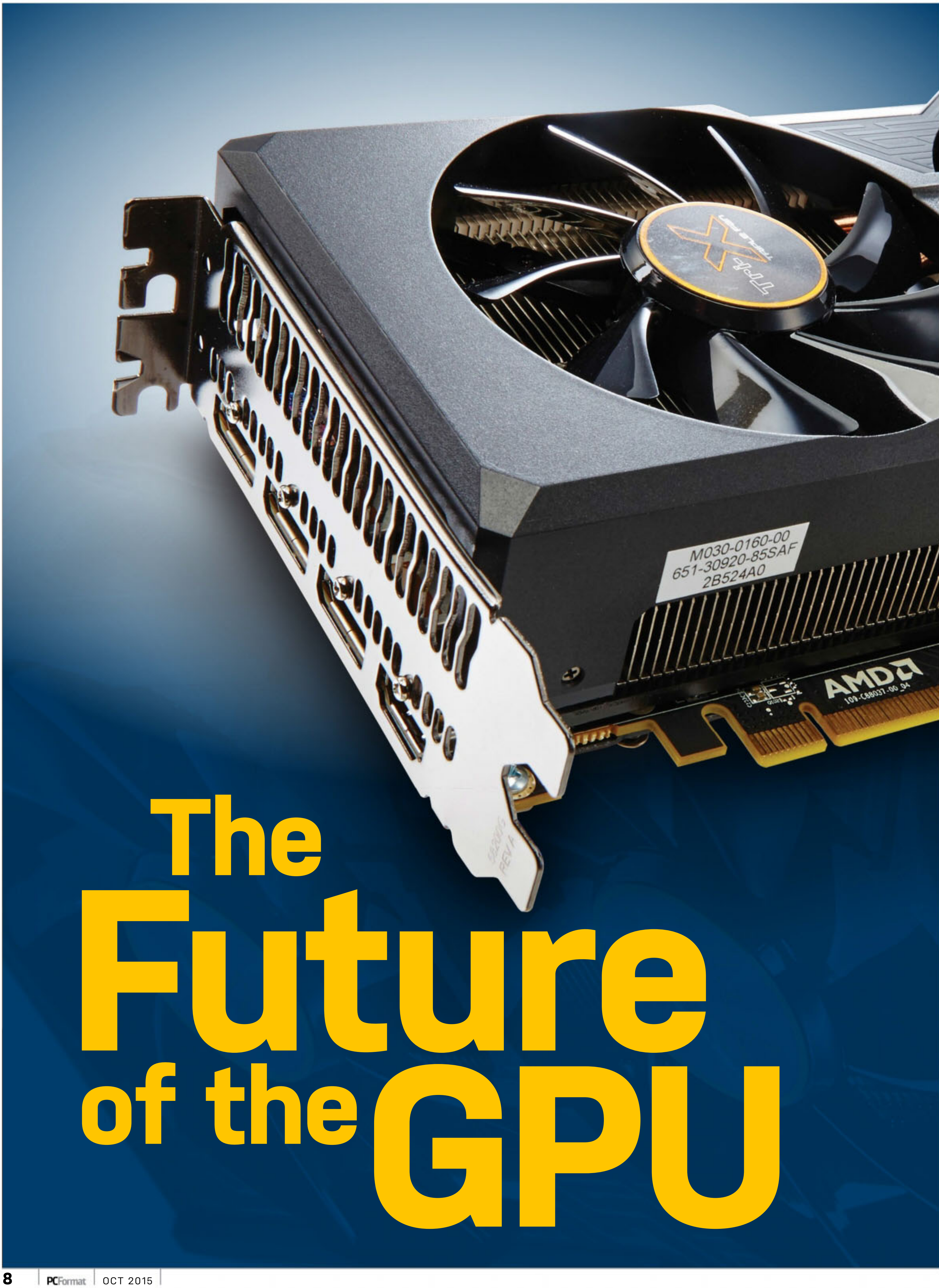
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The Future of the GPU

It could be the perfect time to upgrade your current graphics card, but what do you need to prepare for the GPU future?

By Dave James

THE GRAPHICS CARD is the component most responsible for PC gaming performance. Above everything else in your PC. You could have the most powerful, £800 octo-core Haswell-E CPU in your rig, but if you've got a weedy GPU backing it up, you're never going to be hitting the graphical heights that today's PC games deserve.

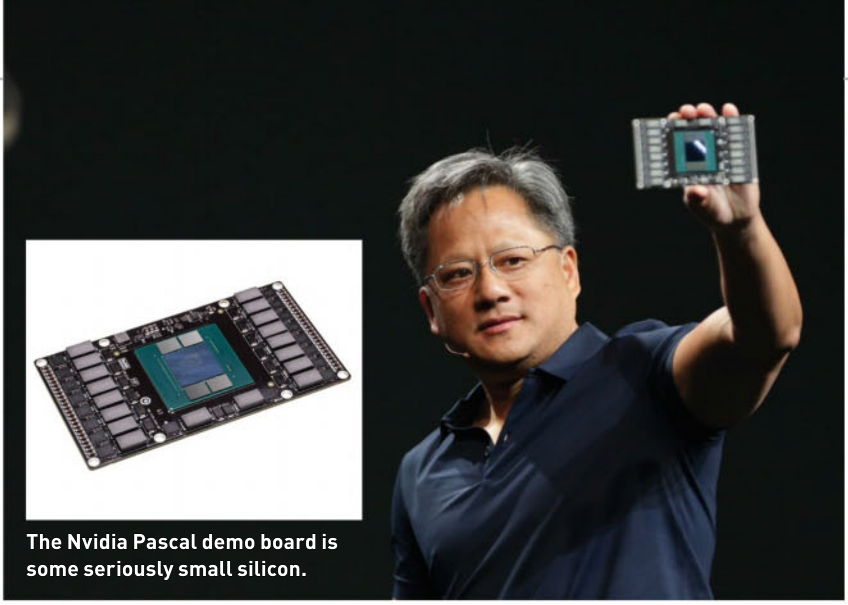
And it's a great time to buy a new graphics card right now. Both the leading lights of GPU development – Nvidia and AMD – have finally released their graphics card lineups for this year, with high-end, ultra-enthusiast GPUs and super-efficient, lower-end offerings. And by the way, for ultra-enthusiast, read: eye-wateringly 'wtf-how-much?!' expensive.

While Nvidia has had it pretty much all its own way since the GTX 980 was released almost a year ago, AMD has finally responded with a slew of new – and some not so new – GPUs to try and put it back in the game. Correspondingly, Nvidia has updated its range and dropped the prices here and there. Who wins? We all do, of course. You can now go and bag yourself a quality, high-end graphics card for some pretty reasonable sums of money. Which is why this month we've got them all into one room for a GPU battle royale.

If this is the state of play in the graphics card market right now though, what does the future hold for this pedigree racehorse of components? Are we likely to have genuinely affordable, genuinely capable GPUs delivering the 4K feels on the next generation of high-resolution gaming monitors? And is the end nigh for the classic peripheral component interconnect express?

Both Nvidia and AMD are set for big new GPU architectures on incredibly tiny production processes in the next year, having both missed out on the bonanza that 20nm lithography was meant to offer. It's set to be a very intriguing time for the not-so-humble GPU then, and with the rise in screen resolution and the burgeoning VR industry's insatiable thirst for GPU power, it needs to be. Let's do some digging and see if we can figure it out what's going on…

Even the Titan X will look weedy against the 16 billion transistors of Pascal.



The Nvidia Pascal demo board is some seriously small silicon.

Before we go too far into a future filled with high-bandwidth memory (HBM), new component interconnects and new GPU architectures, there are still a few holes to be plugged in AMD and Nvidia's respective graphics card lineups.

Scheduled to arrive very soon, possibly by the time you read this, is Nvidia's replacement for the GTX 750 Ti – inevitably named the GTX 950 Ti. The GTX 750 Ti was the first Maxwell-powered graphics card and it makes sense for it to now be refreshed with new silicon. It's more than likely to be sporting a slightly cropped version of the GM 206 GPU found in the current GTX 960.

Like the GTX 750 Ti before it, the GTX 950 Ti (probably set to release alongside the GTX 950) should offer impressive levels of power efficiency combined with decent 1080p gaming performance, too.

“Pascal will be the first Nvidia cards to offer 3D memory – it's set to use HBM 2.0 to achieve a purported 32GB max frame buffer.”

To counter it, AMD is looking to try and spoil the low-end GPU party with its own Radeon 370X, a Trinidad GPU-powered card aiming squarely at the same price point as the GTX 950 Ti. It will essentially be using the same Pitcairn GPU that AMD filled the R9 270X out with, and it will be interesting to see who comes out on top in the battle at the bottom of the market.

There are also rumours that AMD is hard at work putting together a full range of HBM-supported graphics cards to follow the Fiji model used in the Fury cards. Whether that will be as part of an interim refresh of the current chips isn't known, but that's probably unlikely. We expect the current lineup to last until the next AMD GPU architecture drops next year.

BUT WHAT'S NEXT?

With the Maxwell GPU architecture having been around for a good long while now – since early 2014 with the GTX 750 Ti and from last September with the full-fat GTX 980 cores – it's time to start thinking about what's coming next.

The next generation of graphics cards from both Nvidia and AMD is going to see a major cut in the production process. This is the big news from the next round of GPU architecture updates, and also the reason for this current generation being something slightly different to what we originally expected.

When the two companies first started talking about their Maxwell and Pirate Islands GPU ranges, it was largely expected that these would be the first chips to tip up rocking the new 20nm production process. And it wasn't just us expecting that either – both the GPU makers thought they'd be making the move.

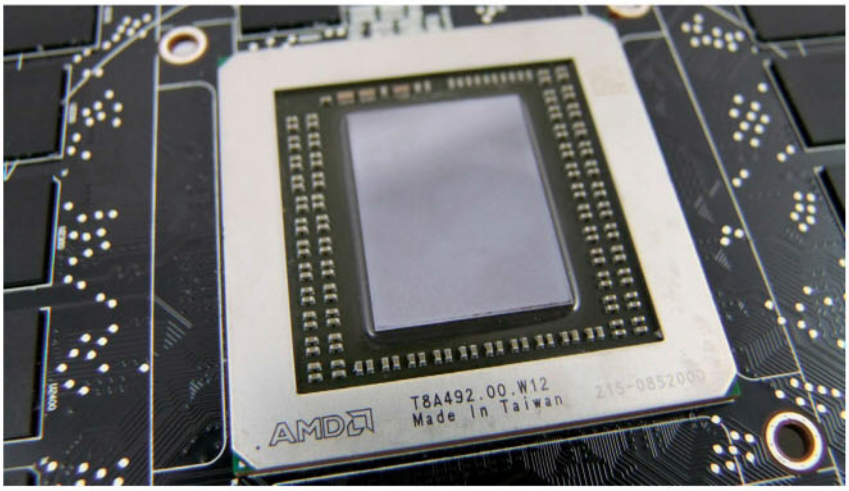
However, the 20nm process turned out to be a nightmare for the silicon makers to produce chips with at a consistent yield without losing a bunch to defective parts in the baking process. This made the whole 20nm lithography seriously expensive. Tied to the fact that it wasn't actually delivering much in the way of performance or efficiency gains, it's unsurprising that the switch wasn't deemed worth it.

So Nvidia and AMD have been stuck on the existing 28nm process for at least one generation longer than either really expected. Nvidia, however, seemed to see the writing on the wall, and, with the already-efficient Maxwell architecture, it was still able to deliver improved GPUs. AMD, on the other hand, has stuck with its existing architecture and simply piled more and more silicon into the design to boost performance.

But the new 2016 GPU architectures from AMD and Nvidia won't be on the 20nm process either. That ship has sailed and now we're expecting both companies to move their chip production process to the new 16nm FinFET (similar to Intel's Tri-Gate 3D transistors) lithography. This will allow far more transistors to be packed into the same, or smaller, die size and yield greater efficiency gains, too.

BLAISE OF GLORY

On the Nvidia side, we're looking at an architecture called Pascal – named after the French physicist Blaise Pascal – and the rumour that the successor to the full-fat GM 200 GPU could have as many as double the transistor count. That would



Sticking with a 28nm GCN chip requires some serious cooling.

The next step for AMD's GPUs is to drop to the 16nm lithography.

The upcoming GTX 950 Ti could well come passively cooled.

give it somewhere upwards of 16 billion transistors. That phrase needs to be read in your head one more time with Carl Sagan's wondrous tones.

The Pascal GPU will be the first of Nvidia's cards to offer 3D memory and is set to use the second generation HBM 2.0 to achieve the purported 32GB maximum frame buffer. One of the struggles with the current HBM tech used on AMD's Fiji cards is that it has a limit of 2Gb per DRAM die, making a maximum of 1GB in a stack, and only four memory stacks per GPU interposer. That's why the Fury cards have a slightly miserly, though speedy, 4GB frame buffer.

HBM 2.0 though is designed to massively boost that upper limit with a limit of 8Gb per die and stacks offering either four or eight dies piled on top of each other. That will give each stack a maximum of either 4GB or 8GB in capacity. With four of those HBM 2.0 stacks arrayed on the interposer around the GPU itself, you're looking at either 16GB or 32GB frame buffers, depending on the SKU.

Pascal is looking to unify its memory, too, making it available to both CPU and GPU. In traditional interfaces, that would introduce latency issues across the PCIe connection when communicating between CPU and GPU. But with Pascal, Nvidia is introducing a new interface called NVLink. On our PCs, however, NVLink-proper looks a while off (see "Is NVLink the end for PCIe?", to the right, for more on that).

AMD ADVANCES

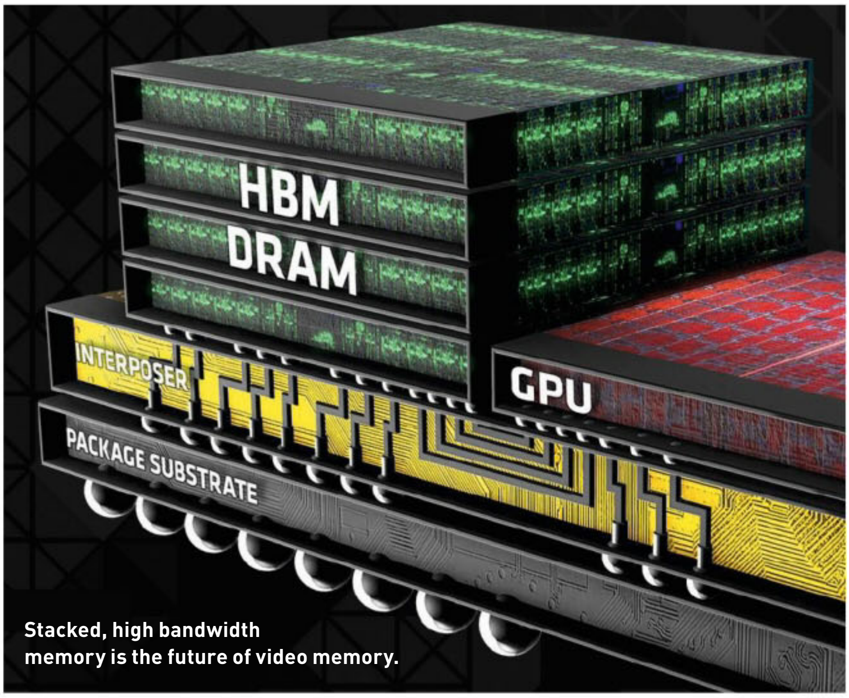
AMD's Arctic Islands architecture – also due in 2016 – could be AMD's first new GPU architecture since the inception of the Graphics Core Next design at the beginning of 2012. It has mentioned a doubling of the performance-per-watt efficiency of its high-performance range of GPUs.

It's unlikely to be too radical a departure from the current GCN architecture though, especially given mixing a new production process with a brand new architecture can be a recipe for disaster. Though that is also the route Nvidia is taking with Pascal…

What we do know is that the successor to the top Fiji GPU of today will have the Greenland codename and will sport the same second-gen memory architecture as the Nvidia cards – HBM 2.0. That will mean huge potential frame buffers all round. The Arctic Islands range will also utilise the 16nm FinFET technology, which is arguably how it's going to be able to nail the 2x perf-per-watt target that AMD has set itself.

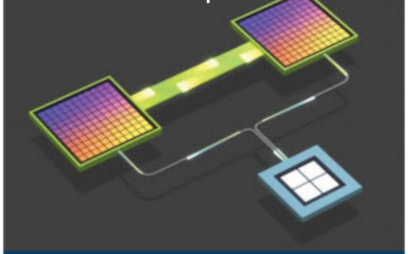
With the introduction of the new lithography and the promise of high bandwidth memory being used throughout the GPU stack, we're pretty confident that Arctic Islands won't suffer from the same rebrand-a-thon woes that have somewhat blighted the current Southern Islands/R300 series release.

All in all, 2016 is looking a seriously exciting year in terms of graphics cards. The efficiency gains from the 16nm lithography will keep things highly chilled in the mid-range, but also allow for some absolute monster GPUs at the top end. Hell, we could be looking towards 8K gaming by then, guys and gals.



Stacked, high bandwidth memory is the future of video memory.

NVLink is going to be used between GPUs on our desktops.



Is NVLink the end for PCIe?

ALONG WITH the announcement of the Pascal architecture, Nvidia CEO Jen-Hsun Huang also introduced the world to NVLink, an interconnect for its GPUs that could potentially offer between five and 12 times the bandwidth of the current PCIe 3.0 connection.

Nvidia's talking about NVLink offering DRAM-class speed and latency, which will allow for the use of Pascal's unified memory across the entire PC. It will also improve performance between GPUs, so multi-GPU systems could end up getting a far more linear scaling in terms of gaming speed.

As well as the NVLink connection on the GPU itself, it will also require dedicated silicon in the CPU if it wants to bypass the PCIe interface completely. From the outset though, that looks likely to be restricted to supercomputer-class high performance computing (HPC); Intel is unlikely to start dropping Nvidia silicon into its designs.

But if there's no path to the CPU, NVLink can just dedicate all its available bandwidth to GPU-to-GPU connections, which is what will potentially enable it to bear fruit in our gaming PCs.

Right now we're a fair way off saturating the available PCIe bandwidth on our rigs. The current interconnect is fine for our present-day needs, but boosting SLI scaling could be a real bonus. In terms of HPC applications, however, there are times when programs are doing large pro-level processing on the GPU – such as image processing for astronomy or seismic processing – and the PCIe interface becomes a serious bottleneck.

For our machines, that's not going to be a problem, and AMD shows no sign of wanting to shift interfaces either. We can't see PCIe going dodo any time soon, at least not in the next couple of years.

TITAN
NVIDIA

Nvidia GTX Titan X

Not winning this clash of cards

NVIDIA'S GTX TITAN X is the pinnacle of today's graphics card technology, a position it's likely to maintain until Pascal tips up, waving its 16nm transistors all up in the GM 200 GPU's silicon face. But that doesn't make it the best card around.

At launch, the £800 price tag seemed insanely, almost offensively, high. Sure, it was the first time we'd seen the much-vaunted GM 200 GPU appear in a form we could jam into our desktop machines, and it is most definitely head and shoulders above the GTX 980 in terms of gaming performance, but it didn't have the same feel as the original Titan.

It lacked the supercomputer, double-precision capabilities for a start, and we never warmed to the black shroud of the 'X' either. The big problem, however, is that card sitting nonchalantly to its right – the GTX 980 Ti.

It was always going to happen. GPU history has taught us that much. But the release of the GTX 980 Ti has rendered the Titan X almost entirely irrelevant. The higher clockspeeds of most iterations of its younger sibling made the difference between core count vanish, and often delivers the GTX 980 Ti a performance lead.

And yet, the Titan X is still almost £200 more expensive, only buying you an extra 6GB on top of the GTX 980 Ti's frame buffer. By the time you need 12GB of graphics memory, the next generation of mid-range GPU tech may well be making this ol' ultra enthusiast card look tired.

SPECIFICATIONS

GPU	GM 200
CUDA cores	3,072
Memory capacity	12GB GDDR5

VERDICT 7

Nvidia GTX Titan X

+ **TITAN** Huge frame buffer; overclockable.

− **TITCH** No double precision; doesn't offer value at super-expensive price.

£820, www.ebuyer.com

Gold
PCFormat
Gold
Accelero
Hybrid S

Inno3D iChill 980 Ti Black

Chilling with the fastest GPU

ANYTHING YOU CAN DO, I can do better, says Inno3D's liquid-chilled GTX 980 Ti, swishing its rubber-tubed tail in the Fury X's direction. This is one of the finest examples of the Titan-killing GTX 980 Ti and shows AMD a thing or two about high-end GPUs.

Rocking almost the same GM 200 GPU as the Titan X, the GTX 980 Ti is missing only 256 CUDA cores and a 6GB chunk of VRAM, but has the same number of ROPs and 336-bit memory bus. Coupled with that stonking GPU, Nvidia has let each manufacturer put their own stamp on the GTX 980 Ti, too. Most cards you see will be factory-boosted units with new cooling arrays bolted on.

That means cards like this Inno3D one here really put the Titan X in its place. It also sits well above AMD's R9 Fury X; its closest rival from the red side. The issue with factory-overclocked cards, however, is that they have a hefty price premium attached, though you can still get more affordable GTX 980 Ti's that give the Titan and Fury X-ers a bloody nose for well under £600. With this card you can get genuinely playable frame rates from the likes of *GTA V* and *Shadow of Mordor*, even at the most strenuous of 4K settings.

This still feels like a ludicrous amount of money to spend on a new graphics card, but for value, it beats the Titan X hands-down. The high-end 4K performance you get with this GPU makes it a mightily tempting proposition and a very aspirational card.

SPECIFICATIONS

GPU	GM 200
GCN cores	2,816
Memory capacity	6GB GDDR5

VERDICT 9

Inno3D iChill GTX 980 Ti Black

+ **CHILLING** Super-speedy; cool; Titan-killer.

− **COLD FISH** Still expensive; not much faster than other 980 Ti's.

£630, www.overclockers.co.uk

AMD Radeon R9 Fury X

Full of sound and fury

WE GENUINELY HAD HIGH HOPES for the Fiji GPU in the latest Pirate Islands range of flagship AMD graphics cards. And then the tantalising promise of the first sub-28nm GPU vanished along with the 20nm process it was supposed to use, leaving us with just the hopes that high bandwidth memory (HBM) might lift this new Radeon high enough to compete with Nvidia's finest.

The struggle with Fiji is that, to all intents and purposes, it represents very little advancement from the previous generation of Graphics Core Next chips. It's just got a lot more logic inside it. If that had been paired with the die-shrink, things might have been rosey. As it is, the 28nm GPU generates a lot of heat (note the water cooler on the vanilla reference board). Even with the huge 4,096 Radeon cores inside, it can't perform as well as the slightly more expensive reference GTX 980 Ti.

It has got the first generation of HBM in there – that's allowed for the smaller form factor, but seemingly little else at the top resolution. At 1440p and 1080p you get a nice uplift over the old Tahiti-powered R9 290X, but when you hit 4K, that 4GB frame buffer just runs out. Because of the limits of first-gen HBM, AMD could only fit 4GB onto the Fiji GPU.

With hugely detailed games such as *Middle-earth: Shadow of Mordor*, *Total War: Attila* and *GTA V* demanding well above that limit, the Fury X quickly bumps into its performance ceiling.

SPECIFICATIONS

GPU	Fiji XT
GCN cores	4,096
Memory capacity	4GB HBM

VERDICT 7

AMD Radeon R9 Fury X

+ **XPERT** Water cooled; next-gen memory.

− **FURIOUS** Can't catch the GTX 980 Ti; only 4GB frame buffer; relatively expensive.

£510, www.ebuyer.com

Sapphire R9 Fury Tri-X

Fast and a little furious

SUCH IS THE WAY with AMD graphics cards – they will almost always arrive two-by-two. When AMD creates a class of GPU, it will generally offer a higher-end XT version and a slightly cut-down Pro version.

The R9 Fury then is the slightly cut-down Pro version of the Fiji XT in the Fury X. The Fiji Pro has 512 fewer Radeon cores than its bigger brother, and a 50MHz drop in base clock, but is happily sporting the same 4GB of HBM for a super-speed frame buffer. It's also around £100 cheaper than the Fury X.

Which leaves us scratching our heads. This Sapphire, Tri-X-cooled version of the Fury actually clocks just 10MHz behind the Fury X and yields almost identical gaming frame rates as the more expensive, water-cooled reference card. Yes, the air-cooled card inevitably runs hotter – by around 15 degrees - but when you're dropping only a few fps on average, but saving £100, it becomes a bit of a no-brainer.

It's still over £400 for effectively a third-tier graphics card, but it will deliver excellent gaming performance and, if you're not going 4K yet, will make your 1440p screen sing. The Fury also goes toe-to-toe with the 980, often taking a performance lead. That has led to some price drops on the older card though, so you can find great deals on the Nvidia side now. But when the price is close, we'd recommend staying with the more-advanced card that's rocking HBM if you're chasing a purchase.

SPECIFICATIONS

GPU	Fiji Pro
GCN cores	3,584
Memory capacity	4GB HBM

VERDICT 9

Sapphire Radeon R9 Fury Tri-X

+ **TRUSTY** Almost as quick as the Fury X; decent cooling.

− **TRIXSY** Expensive; only just faster than 980.

£444, www.scan.co.uk

Palit GTX 980 JetStream

Bon anniversaire, old fella

IT SEEMS FUNNY TO THINK the GTX 980 is almost a year old. It doesn't seem that long since we first plugged the big Maxwell chip into our test rig and were blown away by the unprecedented mix of performance and efficiency.

Despite still being built of the same 28nm transistors as the Kepler generation of graphics cards, Nvidia had managed to tweak its architecture enough that you effectively got all of the benefits of a die-shrink, without having one. Imagine what it would've been like had Maxwell hit the 20nm lithography we expected. Imagine what Pascal is going to be like when it arrives next year.

A year down the line, the 980 is still a great card, especially since the release of the Fury and Fury X has encouraged its first real price drop. With this outstanding Palit card being almost £100 cheaper than the Fury – and a great deal less than the Fury X – it's a fantastic GPU for your 1440p gaming rig.

The GPU here is seriously overclocked, as the GTX 980 is generally capable of, and comes with a 0dB cooler that only really needs to kick in at peak gaming performance.

Right now though, 1440p is the limit of the 4GB frame buffer the GTX 980 sports. So 4K gaming is possible, but too much of a compromise for this card. It's a toss-up between this and the Fury, and in the end it's going to come down to finances and personal preference. The Fury is quicker and has superior memory tech, but the GTX 980 is cheaper and less power hungry.

SPECIFICATIONS

GPU	GM 204
CUDA cores	2,048
Memory capacity	4GB GDDR5

VERDICT 8

Palit GTX 980 Super JetStream

⊞ **JET** Still a great GPU; quality cooling; sterling 1440p perf.

⊟ **WINGS** Not a 4K gamer, with that 4GB VRAM.

£357, www.nigelohara.com

XFX Radeon R9 390X

Deserving of a new name?

IT'S REALLY EASY to get caught whining about feeling misled about this generation of AMD cards. The Fury cards and their Fiji GPUs are the only new graphics silicon AMD has really put the time into for this year's launch. Everything else is essentially a re-branded version of the last-gen option, with a few light tweaks here and there.

But those tweaks have made a real difference. While this Grenada XT GPU is little more than the Hawaii XT chip from the ol' R9 290X, AMD has squeezed a little more speed from its clocks – an extra 50MHz – and bundled in double the memory. Whether that's enough to mean the GPU deserves a new name is neither here nor there.

While the R9 390X is a lot quicker than the R9 290X it's replacing, it's also effectively the same price. Now, before we get ahead of ourselves, that 8GB frame buffer isn't going to suddenly deliver 4K gaming performance for this ageing architecture – there's almost no difference between the 290X and 390X at the highest resolution – but it does deliver performance improvements almost across the board at lower levels.

Almost… because we did experience some weird issues with this card and *GRID 2*. But for everything else, even the demanding *GTA V*, it delivered impressive performance figures. Most obviously in the minimum frame rates, especially with Rockstar's modern classic.

But its li'l brother, the straight R9 390, is the issue here. It's practically as good, with a notable saving too.

SPECIFICATIONS

GPU	Grenada XT
GCN cores	2,816
Memory capacity	8GB GDDR5

VERDICT 7

XFX Radeon R9 390X

⊞ **GRENADA** Hefty frame buffer; quality 1440p performance.

⊟ **GRENADE** Re-branded GPU; R9 390 is almost as good.

£310, www.ebuyer.com

Sapphire R9 390 Nitro

Hawaii Pro, with added nitrous

AMD ALWAYS SEEMS to pull off the same trick; release two cards based on very slightly different GPUs, with very slightly different performance numbers, and demand a lot more for one than the other.

Inevitably, we then look at the lower-spec card with almost the same gaming prowess and question why anyone would pick the pricier option. Such is the way with the Fury and Fury X. Such is the way with the 290 and 290X. And so it is with the 390 and 390X.

And when you throw into the mix that this new Sapphire Nitro branding means this overclocked card gets a Tri-X cooler attached to it, you know things aren't looking too good for the 390X. Couple all that with the fact the 390 also performs better than the top AMD GPU of the last generation and we have a great mid-ranger on our hands.

With most games you'll get excellent 1440p performance out of it, and for a pretty impressive price, too. That Sapphire cooler on this version means it maintains a chilled disposition even in the most aggressive of gaming arenas, and the 8GB frame buffer means it can take every high-res texture that *GTA V* or *Shadow of Mordor* cares to toss its way.

It may be another exercise in re-badging GPUs for AMD, but the little tweaks the team has made to this card's silicon have made it very much worth the effort. We may not be hugely impressed with the Fury, but the work it has done on the 390 almost makes up for it.

SPECIFICATIONS

GPU	Grenada Pro
GCN cores	2,560
Memory capacity	8GB GDDR5

VERDICT 9

Sapphire R9 390 Nitro

+ **NITROUS** Faster than the 290X; almost as quick as the 390X; enormo-buffer.

− **NOXIOUS** Old architecture; drops frames to the 970.

£265, www.scan.co.uk

Gigabyte GTX 970 G1 Gaming

Ignore the shenanigans

THERE'S GENUINELY a lot to like about the GTX 970, despite all the grumbling surrounding its offset frame buffer. It's a good gamer and comes at a decent price, too.

The issue is that Nvidia didn't disclose the smart work it had done with the GPU and the VRAM. To ensure it kept more of the actual GPU logic, Nvidia's engineers did some clever stuff splitting the frame buffer. Had it not done so, the chip would have lost a lot more of the good stuff. Unfortunately, it didn't disclose this and we saw games using over 3.5GB of VRAM struggling on the GTX 970.

But then this isn't a GPU you'd use for seriously taxing 4K gaming, anyways. You can get up there in the VRAM stakes with gaming at 1440p – *GTA V* and *Mordor*'s texture packs do that – but elsewhere, the GTX 970 really fits the bill for a mid-range graphics card.

And Gigabyte's version comes with the excellent triple-fan Windforce cooler, which allows this card to be seriously overclocked without melting a hole in your motherboard. Even at its hottest, it doesn't top 64ºC.

Its biggest rival is that impressive R9 390. These two GPUs trade blows across most of our benchmarking suite, with AMD taking the lead in one test and Nvidia winning others. Where the 390 does win though is in the more modern games, which need over and above the 3.5GB / 4GB frame buffer this card is sporting, even at 1440p. That, and the fact the AMD card is cheaper, means we give the nod to the 390 here.

SPECIFICATIONS

GPU	GM 204
CUDA cores	1,664
Memory capacity	3.5 + 0.5GB GDDR5

VERDICT 8

Gigabyte GTX 970 G1 Gaming

+ **G1** Cool 'n' quick; decent price.

− **M25** Pricier than the 390; suffers at top settings in modern games; frame buffer-gate.

£275, www.ebuyer.com

Asus GTX 960 STRIX

2GB just ain't enough any more

THE GTX 960 IS PRETTY MUCH the bottom of the ladder when it comes to the modern Maxwell lineup – until the GTX 950 arrives to replace the ol' GTX 750 GPUs, anyways. And what that means is we're talking about a resolutely 1080p gamer's card.

You can, of course, run a 4K monitor from this GPU, but even at 1440p settings, you'll struggle to play the latest games at top settings with any semblance of buttery smooth gaming. Throw this Asus STRIX card at anything running on a 1080p screen, though, and that's exactly what you'll get. *BF4* runs like a dream at top settings and you can get great performance out of *GTA V*, too. *Shadow of Mordor*'s texture pack, though, is still seriously demanding, even at 1080p, so we only saw 36fps on average, which is still just about acceptable.

The big issue with this card is that 2GB frame buffer. Where once that was plenty, in this brave new resolution-heavy world of ours, it's simply not enough for the most demanding of games and is likely to leave you wanting when new titles drop in the big autumn gamegasm.

But when it's coated in Asus's STRIX armour, it's still a tempting sub-£200 GPU. The 0dB cooler only spins up when you get up to gaming speeds and even then this card stays seriously cool and quiet. At this end of the market though, AMD has got it sewn up again. The competing R9 380 is similarly priced and rocks that 4GB frame buffer to give it some much-needed longevity.

SPECIFICATIONS

GPU	GM 206
CUDA cores	1,024
Memory capacity	2GB GDDR5

VERDICT **7**

Asus GTX 960 STRIX

⊞ **STRIX** Low-powered; decent at 1080p.

⊟ **STRUCK OUT** Weedy frame buffer; fails at 1440p top settings; the 380 takes it.

£169, www.scan.co.uk

MSI R9 380 Gaming 4G

Something old, something new

WE'VE GIVEN AMD a little bit of strife for the whole rebranding thing with this current generation of GPUs. And it does feel a little like the company is treading water until either TSMC or Global Foundaries get their 16nm acts together and provide it with a production process for the future. Which is all to say the R9 380 is another old-school GPU; though this is actually the second-most modern after the Fiji chips.

The Antigua GPU at the heart of the R9 380 is essentially the Tonga silicon from the previous generation. That means it's got the latest class of GCN architecture, rocking the same 256-bit memory bus as the R9 285 because of the lossless colour-compression tech boosting its memory performance.

That's some modern AMD goodness that's missing from the higher-end 390 cards. The real big win for this card is – and we know we keep harping on about it – the chunky memory buffer. With 4GB on this relatively low-end GPU, you're getting a quality 1080p gaming card that's more than capable of mixing it with the most graphically demanding games of now and tomorrow.

The 2GB buffer of the GTX 960 is what's holding it back, but with double that capacity, the R9 380 is a far more capable gamer, even offering very playable performance at 1440p too. Where you do need to be careful though is with the 2GB versions of the R9 380 that are floating around. Those are definitely to be avoided.

SPECIFICATIONS

GPU	Antigua
GCN cores	1,792
Memory capacity	4GB GDDR5

VERDICT **8**

MSI R9 380 Gaming 4G

⊞ **GAMING** Beefy buffer; decent at 1080p; great MSI cooler.

⊟ **GAMMY** Avoid the 2GB; 4GB is pricey.

£179, www.dabs.com

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HOW WE TESTED

Our test rig comprises an Intel Core i7-5960X in an Asus X99-Deluxe motherboard with 16GB of 2,133MHz DDR4 memory under Windows 8.1. All of the graphics cards are tested with the latest release drivers on the same benchmark settings to ensure a fair test. We've included the minimum frame rate results as well as the overall average to indicate how smooth an experience you're getting from each graphics card.

SPECIFICATIONS

	Website	Price	GPU	Cores	Memory capacity	Memory bus	TDP	Peak temperature °C	Score
Nvidia GTX Titan X	www.nvidia.com	£830	GM 200	3,072	12GB GDDR5	384-bit	250W	83	7
Inno3D iChill GTX 980 Ti Black	**www.inno3d.com**	**£630**	**GM 200**	**2,816**	**6GB GDDR5**	**384-bit**	**250W**	**68**	**9**
AMD R9 Fury X	www.amd.com	£510	Fiji XT	4,096	4GB HBM	4,096-bit	275W	64	7
Sapphire R9 Fury Tri-X	www.sapphiretech.com	£444	Fiji Pro	3,584	4GB HBM	4,096-bit	275W	79	8
Palit GTX 980 Super JetStream	www.palit.biz	£357	GM 204	2,048	4GB GDDR5	256-bit	165W	75	8
XFX R9 390X	www.xfxforce.com	£310	Grenada XT	2,816	8GB GDDR5	512-bit	275W	80	7
Sapphire R9 390 Nitro	www.sapphiretech.com	£269	Grenada Pro	2,560	8GB GDDR5	512-bit	275W	71	9
Gigabyte GTX 970 G1 Gaming	www.gigabyte.com	£275	GM 204	1,664	3.5 + 0.5GB GDDR5	256-bit	145W	64	8
Asus GTX 960 STRIX	www.asus.com	£169	GM 206	1,024	2GB GDDR5	128-bit	120W	64	7
MSI R9 380 Gaming 4G	www.msi.com	£179	Antigua	1,792	4GB GDDR5	256-bit	190W	78	8

1920 X 1080 BENCHMARKS (1080p)

	Battlefield 4	Total War: Attila	GRID 2	GTA V	Shadow of Mordor
Nvidia GTX Titan X	64 / 122	21 / 43	**132 / 180**	12 / 103	49 / 108
Inno3D iChill GTX 980 Ti Black	**87 / 134**	**36 / 45**	121 / 177	**8 / 115**	**48 / 123**
AMD R9 Fury X	60 / 100	29 / 39	114 / 146	10 / 88	47 / 98
Sapphire R9 Fury Tri-X	61 / 97	28 / 37	100 / 134	31 / 85	29 / 93
Palit GTX 980 Super JetStream	62 / 113	23 / 36	129 / 162	21 / 87	42 / 89
XFX R9 390X	48 / 90	18 / 31	62 / 77	21 / 78	40 / 83
Sapphire R9 390 Nitro	47 / 82	21 / 30	91 / 118	20 / 74	38 / 79
Gigabyte GTX 970 G1 Gaming	47 / 90	21 / 30	104 / 131	21 / 75	50 / 74
Asus GTX 960 STRIX	31 / 55	9 / 18	71 / 88	9 / 49	17 / 36
MSI R9 380 Gaming 4G	34 / 53	11 / 18	73 / 87	12 / 48	18 / 45

2560 X 1600 BENCHMARKS (1600p)

	Heaven	Battlefield 4	Total War: Attila	GRID 2	GTA V	Shadow of Mordor
Nvidia GTX Titan X	19.8 / 60.4	46 / 83	19 / 28	105 / 138	**7 / 70**	48 / 74
Inno3D iChill GTX 980 Ti Black	**19.6 / 70.7**	**64 / 99**	**20 / 32**	**118 / 157**	**7 / 70**	**50 / 85**
AMD R9 Fury X	19.4 / 49.9	36 / 73	18 / 27	90 / 111	10 / 62	35 / 71
Sapphire R9 Fury Tri-X	19.8 / 46.9	40 / 69	18 / 25	82 / 105	16 / 61	32 / 67
Palit GTX 980 Super JetStream	18.2 / 48.6	42 / 73	13 / 23	93 / 118	16 / 57	36 / 61
XFX R9 390X	16.7 / 38.8	35 / 61	14 / 21	62 / 77	17 / 55	29 / 58
Sapphire R9 390 Nitro	15.9 / 37.8	34 / 58	13 / 20	70 / 88	15 / 52	28 / 56
Gigabyte GTX 970 G1 Gaming	15.4 / 38.4	34 / 57	13 / 19	76 / 96	19 / 49	38 / 51
Asus GTX 960 STRIX	10.5 / 23.1	23 / 37	6 / 11	48 / 59	6 / 31	14 / 24
MSI R9 380 Gaming 4G	11 / 23.6	25 / 39	7 / 12	46 / 57	11 / 34	10 / 35

3840 X 2160 BENCHMARKS (4K)

	Heaven	Battlefield 4	Total War: Attila	GRID 2	GTA V	Shadow of Mordor
Nvidia GTX Titan X	17.5 / 26.5	25 / 43	6 / 14	59 / 78	11 / 36	29 / 38
Inno3D iChill GTX 980 Ti Black	**13.3 / 29.3**	**30 / 49**	**9 / 17**	**71 / 91**	**9 / 41**	**35 / 46**
AMD R9 Fury X	11.6 / 22.7	21 / 40	3 / 12	57 / 70	3 / 35	18 / 38
Sapphire R9 Fury Tri-X	10.8 / 21.3	23 / 38	7 / 12	50 / 66	1 / 33	14 / 36
Palit GTX 980 Super JetStream	10.3 / 20.6	23 / 38	6 / 11	46 / 67	6 / 23	26 / 33
XFX R9 390X	9.5 / 17.3	19 / 31	6 / 10	44 / 55	12 / 28	22 / 31
Sapphire R9 390 Nitro	9.3 / 16.4	17 / 30	6 / 10	41 / 52	12 / 26	17 / 31
Gigabyte GTX 970 G1 Gaming	9.2 / 16.2	17 / 29	4 / 9	39 / 54	12 / 24	19 / 27
Asus GTX 960 STRIX	5.8 / 9.6	6 / 12	1 / 4	27 / 35	2 / 8	6 / 12
MSI R9 380 Gaming 4G	7 / 11.1	10 / 19	1 / 6	29 / 36	4 / 11	8 / 20

Best scores are bolded. Overall winner is highlighted. Game results are all minimum/average fps.

Accelero
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Gold

And the winner is...

Inno3D iChill GTX 980 Ti Black

WE'RE AT A WEIRD MOMENT in the history of graphics cards. On the one hand, it's a fantastic time to go out and buy a new GPU because there's simply never been this amount of GPU processing power available at any price.

On the other hand, though, you've got a vast number of cards still rocking ageing graphics architectures with potentially hugely updated versions on the way. That means, of the cards we've got in our test this month, only a few of them could genuinely be recommended for purchase right now.

The top-end of the market is the toughest – mostly because, and we can probably all agree on this, pricing has become utterly insane. At the top of the pile is Nvidia's GTX Titan X, at £800. Mental. And now it's not even the fastest card, only holding its 12GB frame buffer over the rest of the graphics market.

Then we've got AMD's only genuinely new GPUs of this latest, late generation. The two Radeon Fury cards simply don't do anything to make them worthwhile. They are cheaper than the top Nvidia cards, but lose out in the performance stakes despite having that brand new memory technology. They only have 4GB each, and that's simply too little to expect to hit high-res gaming speeds in the future of gaming.

ALL-ROUND CHAMPION

Up top then – and probably overall – the GTX 980 Ti is the only high-performance card worth spending money on right now. The 6GB frame buffer and exceptional gaming performance will mean that, even when the 16nm GPU revolution happens next year, it will still be able to hold its head up high in the performance stakes.

Nvidia's old GTX 980 could still be worth a punt if you can find it for closer to £300 – again, it's not going to cope well with the 4K future with its older GPU and 4GB frame buffer, but it's an absolute rock at 1440p. This Palit version is super-quiet and super-cool.

Surprisingly, the re-branded Hawaii cards, specifically the excellent R9 390, have made themselves more worthy than we initially expected. The 390X is impressive for the fact it outperforms its 290X forebear. But then so does the straight 390, and for considerably less cash.

And that 8GB memory capacity means the 390 is going to still be gaming happily at 1440p for a good while to come, even when the Arctic Islands and Pascal GPUs arrive sometime next year. This Sapphire R9 390 Nitro is the other bright spot in our supertest, and is the one we'd recommend for a mid-range card.

Down at the bottom of the pile, the much-maligned GTX 970 still has some skills, but with the performance of the 390 and its hefty frame buffer, the GTX 970 is not going to be able to stand out against the AMD card.

And propping things up at the real budget end, where the GTX 960 goes head-to-head with the R9 380, we've again got to hand the glory to the Radeon offering. And yet again, that's down to the additional frame buffer. The 4GB capacity of the R9 380 isn't going to mean you can suddenly nail super-high resolutions, but it does mean that at a more standard resolution, it's going to cope with even the most demanding of future titles. ■

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HARDWARE

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Curse Your Sudden, Inevitable Betrayal

Wondering whether any older prebuilds are worth it now

> "I'm going to tell you this. Do not buy a prebuilt if it has a Haswell processor."

WELL, THIS ISSUE is certainly crammed to the brim with lovely Skylake stuff, isn't it. I have to admit, I didn't realise how much we'd be talking about it this time around. It's a biggie.

It doesn't sound like a lot, but after four years of a 10 per cent performance increases, it's become increasingly tempting to upgrade to Intel's latest platform. I'll admit, I'm still using an Intel Core i5-2500K at home. She's still rocking along, quite solidly at 4.8GHz, as my daily driver. But with Skylake hitting the playing field, it might finally be time for me to take that plunge and start prepping for a new rig (in fact, I already have one in mind that you guys will be seeing in a future issue).

But that's not what I'm here to talk about. We review a lot of prebuilt machines – Cyberpower, Aria, Scan, Chillblast, Vibox. You name it, we cover them, and they vary massively from one end of the spectrum to the other. We'll almost always advocate building your own rig here, but if you just don't have the time or don't want to bother yourself with the technical know-how, a prebuilt is the best way forward.

At the moment, however, we're stuck in this almost transitional phase between Intel's long-awaited refresh and Devil's Canyon. Skylake is a big step up from the traditional refreshes. And although people will no doubt be complaining about how Intel didn't need to recreate the socket (especially considering there's an entire one pin difference twixt the two), there's a lot of new features that simply couldn't have happened if we hadn't moved on up to a new series of boards. Besides, I've never understood the desire to upgrade a chip and not a motherboard. Half the new features you get come from the chipset itself, not the CPU.

So, if Skylake is such a huge jump from the last generation of processors, is there any point in buying a prebuild that features the Z97 chipset and Haswell? It's hard to say at this point. For price to spec you'll find you can actually match the same setup between the two platforms. The problem lies with system builders. They'll no doubt have a lot of excess stock, and will try to palm your coin from your hands and into their profit margins. Understandable, of course. That's good business. But honestly, I'm going to tell you this. Do not buy a prebuilt if it contains a Haswell processor or the Z97 chipset. Do not do it. Unless it's significantly less money.

At this point, of course, I'll suggest you build your own rig – there's no better place to start for price to performance ratio. You'll know every part going into it, you'll know if you're wasting money on components you don't need, and more often than not, you'll be able to optimise it perfectly for your needs. Better yet, there's not even a lot of technical know-how needed to it anymore. Building a PC today is the same as playing with adult Lego. Very expensive adult Lego. But still Lego. –**ZAK STOREY**

DEEP DIVING INTO SKYLAKE PG. 58

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OUR HARDWARE MANIFESTO

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Streacom F12C

Editor's One to Watch

Did you know that NAND is 25 years old?

TUESDAY, 28 AUGUST, roughly 5pm, marks a very important date. At least, potentially. Intel and Micron will announce the release of a brand new memory technology called 3D Xpoint. It's the first major advancement in memory storage in the last 25 years. Indeed since the introduction of NAND flash, a technology literally older than I am.

But what is it? Why is it so exciting? To put it simply, if Intel and Micron's marketing pitch is anywhere near close to reality, we're looking at storage speeds over 1,000 times faster than that of traditional NAND flash-storage devices (also known as SSDs).

Not only does it tout some insane potential speeds, it also has the same increase to durability and endurance. On top of that, it's 10 times denser than the memory cells found in DRAM, while also remaining non-volatile. And, although this works out to be just a little bit slower than DDR4, the fact it's non-volatile means you can actually store data on it without losing it when the system is powered off, unlike its random access predecessor.

Sounds too good to be true, right? Not so fast. Although Intel hasn't revealed what kind of devices it's going to pack this technology into just yet, we can only assume that it may end up in a traditional form factor similar to 2.5-inch SSDs – more than likely utilising Intel's U.2 port, or Thunderbolt 3 perhaps.

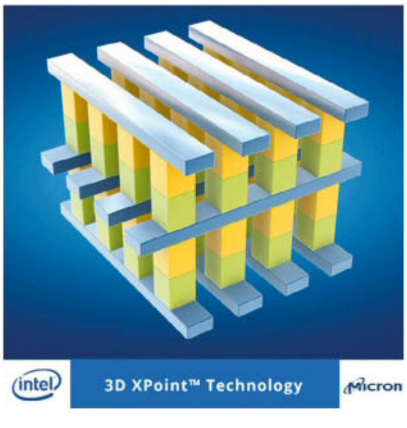
We're talking instantaneous boot times, and read and write speeds somewhere within the region of 552,000MB/s. At this point, you're probably thinking: "Yeah great, but this is going to cost $1,000,000 and only be available to enterprise users." You'd be right to be cynical on this one, as new tech often costs the earth.

However, we've spoken to Greg Matson, director of strategic planning and marketing for Intel's snappily named Data Center Solid-State Drives Non-Volatile Memory Solutions Group, and he suggested that products featuring 3D Xpoint would be appearing in the market some time during 2016. And yes, for both enterprise and consumers.

Intel is still keeping a lot of the finer details under wraps, as to what the products may be, and how the technology is built exactly. However, it's expected to be priced, per GB, somewhere between SSD and RAM storage. Additionally, it's meant to just 'slot in' to any existing system and work straight out of the box, without any need to rework or rebuild programs, hardware or drivers. Although, to get the most out of it, those savvy tech engineers do need to get onto it.

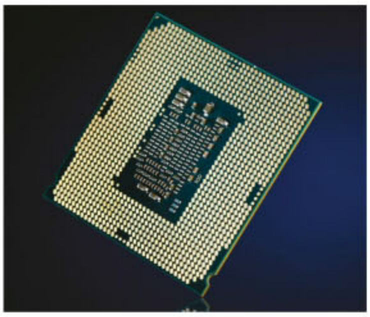
What we do know about Intel and Micron's latest invention is *roughly* how it works. They've removed the element of a transistor entirely. Instead of the data being dependent on that component holding the 1 or the 0 as an electron charge, it's now a solid material based on resistance. So, a 1 would be a high level of resistance and the 0 a low level. Each cross point where the two interlacing lattices meet is where this information is held. And thus, here you have your 3D stackable cross-point memory. Simple. Right?

Well, not quite. We still don't know what material the conglomerate is using to power all of this fandangled tech, and I don't think Intel will be sharing this information with anyone anytime soon. What it has announced is only that it can build it, and it won't be licensing it out to anyone anytime soon. Certainly one to watch for the future.



It's all about resistance, you see.

HIGHLIGHTS THIS MONTH...



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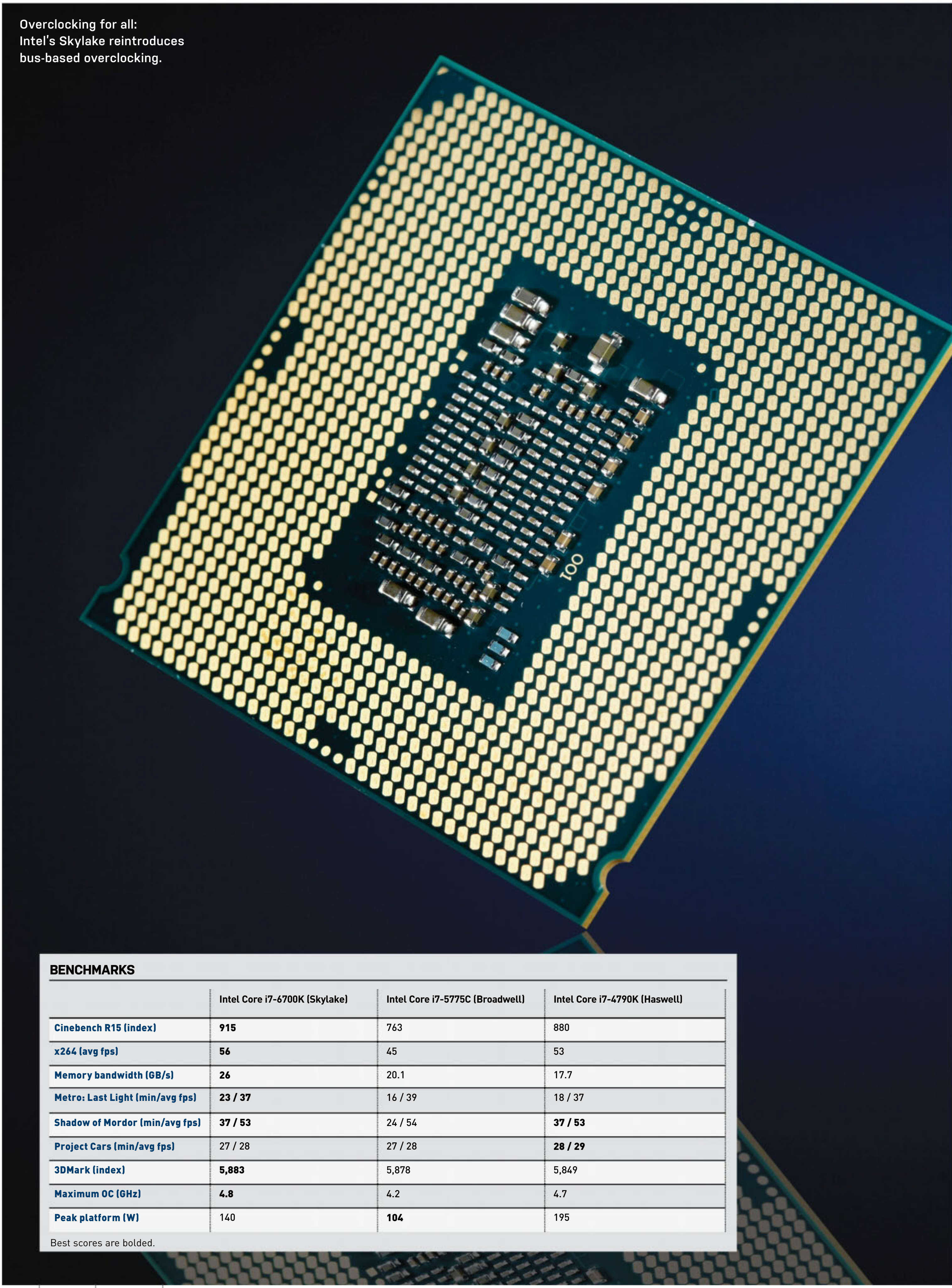

Overclocking for all: Intel's Skylake reintroduces bus-based overclocking.

BENCHMARKS

	Intel Core i7-6700K (Skylake)	Intel Core i7-5775C (Broadwell)	Intel Core i7-4790K (Haswell)
Cinebench R15 (index)	**915**	763	880
x264 (avg fps)	**56**	45	53
Memory bandwidth (GB/s)	**26**	20.1	17.7
Metro: Last Light (min/avg fps)	**23 / 37**	16 / 39	18 / 37
Shadow of Mordor (min/avg fps)	**37 / 53**	24 / 54	**37 / 53**
Project Cars (min/avg fps)	27 / 28	27 / 28	**28 / 29**
3DMark (index)	**5,883**	5,878	5,849
Maximum OC (GHz)	**4.8**	4.2	4.7
Peak platform (W)	140	**104**	195

Best scores are bolded.

Core i7-6700K

Another quad-core? Yup, but this one's different...

FIRST THE BAD BIT. The all-new Intel Core i7-6700K does not tear PC gaming a new one. It's not a render monster like none before. It doesn't take desktop number-crunching to a whole new level. Bummer.

Instead, it's yet another bleedin' Intel processor with four cores, eight threads and a habit of humming along at about 4GHz. Isn't that what Intel's top processors for its mainstream platforms have looked like forever? In fact, it's the way things have been since the arrival of Sandy Bridge, all the way back in late 2010.

Of course, we've been complaining about the glacial rate of progress at Intel for so long now that you might expect this latest mediocrity to have us pondering the possibility of putting an end to it all by stringing ourselves up with SATA cables. After all, you could say the aforementioned glacial progress thing is actually a bit kind. If anything, Intel has actually backtracked in recent years, courtesy of silliness such as dumbed-down chip packaging and cooling, along with increasingly locked-down overclocking.

CORE OF THE ISSUE

So it's true, we're not exactly blown away by this new chip itself. And yet, it's still the most exciting, mainstream Intel CPU for years. How so? Let's start with the basics, even if they are a bit boring.

The Core i7-6700K is one of two launch chips representing the new Skylake family of 14nm CPUs. The other is the Core i5-6600K. This i7 and its quartet of unlocked Hyperthreaded cores rocks in at 4GHz nominally, with a 4.2GHz Turbo clock. Yup, just 200MHz-worth of Turbo boost. Why even bother?

Anyway, it slots into the new LGA1151 socket and thereby hooks into Intel's new 100-series chipsets, the most notable of which, for we performance junkies, is the Z170, which effectively replaces the old Z97. Graphics-wise, there's an Intel HD Graphics 530 core onboard, and thus not one of the fancy new Iris or Iris Pro solutions. Got dat?

Whatever, Skylake is a 'tock' in Intel's tick-tock chip development parlance, and that means it's supposedly an all-new processor design on an existing production node, in this case 14nm. Except, we've barely seen any of the first 14nm chips, known as Broadwell, on the desktop. And now Skylake is go for launch. Put simply, Intel's CPU roadmap has gone completely out of whack.

The other problem, when it comes to improving CPU performance, is that Intel's CPU engineers snaffled up all the low-hanging fruit long ago. Then they climbed the branches and grabbed everything else. And now there's almost nothing left. Intel's CPU cores are outrageously optimised.

That explains why our benchmark results show such a modest uptick in raw CPU performance. It's all of 4 per cent faster than the existing Core i7-4970K in Cinebench. Bleh. As for video encoding, you're looking at a 6 per cent leap. Hardly exciting stuff.

INCHING FORWARD

The game benchmarks are arguably even less dramatic. At the kinds of resolutions that a fairly pricey chip like this is likely to find itself operating, the impact of the 6700K is slim going on none. If you've got a fast Intel Haswell process or an Ivy Bridge chip, hell, maybe even a Sandy Bridge chip, you probably won't feel much subjective difference with Skylake. It's just not a big enough step forward. And if you're wondering why the weirdo chip that is the Broadwell Core i7-5775C has the edge in some of the game benchmarks, that's probably thanks to the 128MB of eDRAM, something the new Skylake Ks lack.

The two obvious solutions to this problem, of course, are clockspeed and cores. Faster clocks or more cores would give added punch, even if the cores themselves remained essentially the same. The problem is that Intel gave up on chasing clockspeeds a decade ago and it's simply not under enough pressure from AMD to force it to add more cores to its mainstream chips.

Indeed, some would argue more cores wouldn't help much in most apps, including games. But we're not so sure. Build it and they will come has been an effective policy for the PC in years gone by. If six cores for gamers became the norm, game developers would make use of them.

But never mind that. So far, we've painted a picture of an unexciting CPU that's part of a fairly broken CPU launch schedule from Intel. Where the hell does the excitement come in? Platform details and overclocking are the answers.

HIGH HOPES

For starters, Intel has doubled the performance of the DMI interface that links the chipset to the CPU. That means you can hook up a really fast M.2 SSD with four PCIe lanes to the chipset and get the maximum possible performance out of it. Yay.

But the best bit involves overclocking. There are a few changes that are significant, and for the most part they are really good news. For starters, there's no more baseclock strap, so you have full access to baseclock overclocking. In other words, on paper you can overclock these things via the bus like the good old days of the LGA775 socket and earlier.

Then there's the voltage regulator that's been taken off the CPU and put back on the motherboard, giving finer control of voltages for different sections of the chip. Finally, don't forget those 14nm transistors. They should be hot for some overclock trot, no?

In the case of this Core i7-6700K, the full overclocking potential isn't that spectacular. We've got two Core i7-6700Ks in for testing. One hit 4.8GHz, the other 4.6GHz, albeit the latter was on a different motherboard, which could skew the results, especially as the motherboard is now responsible for voltage regulation.

What's really exciting is that we achieved the same overclocking results using the baseclock as the CPU multiplier. So here's the bombshell. This could mean that the days of buying a cheaper chip and clocking the twangers off it could be about to return. For now, the jury is out. And the 6700K itself isn't hugely exciting. But what it hints at for possible cheaper Intel processors in the near future is utterly tantalising. Fingers crossed. **–JEREMY LAIRD**

VERDICT 7

Intel Core i7-6700K

⊞ **SKY'S THE LIMIT** 14nm goodness; It's a bit faster; Intel has opened up the overclocking.

⊟ **PIE IN THE SKY** It's not a lot faster; it's still four cores; pricey at launch; Intel's product strategy has gone walkies.

£320, www.intel.com

SPECIFICATIONS

Cores/threads	4/8
Process tech	14nm
Clockspeed	4GHz / 4.2GHz Turbo
Architecture	Intel Skylake
Socket	LGA1151
Cache	8MB
TDP	91W
Memory	DDR4 up to 64GB
PCI Express	16 (CPU) + 20 (chipset)
Graphics	Intel HD Graphics 530

Asus Z170-A

All the Intel Z170 motherboard you actually need?

REMEMBER WHEN LIFE WAS SIMPLER? When there were only a few kinds of coffee? When the lower orders knew their place? And when a USB port was just a bloody USB port? Well, wake up and smell the bandwidth because things have become an awful lot more complicated. Enter the Asus Z170-A and its plethora of USB ports.

Part of the problem is avoidable and entirely the fault of motherboard makers. You see, they've taken to dressing up the USB 3.0 5Mb/s standard as USB 3.1 gen1, at the same time as calling what used to be USB 3.1 10Mb/s, USB 3.1 gen2. It's all baffling and making a bad situation worse.

Check out the rear panel on the new Asus Z170-A. It packs no fewer than three different types of USB ports. You've got your common or garden USB 2.0 ports. Then there's some USB 3.0 ports (or USB 3.1 gen1 ports if you're a silly mobo maker) and a lone USB 3.1 socket. Rounding it out is the real newbie, a USB 3.1 Type-C port, which is much smaller than a standard Type-A port and reversible, which means you can just stuff the connector in and it'll work, like Apple's Lightning connector.

Of course, that USB complexity applies to all of the Z170 boards we've seen. So what marks out Asus's Z170-A? Not its build quality, that's for sure. The PCB is skinny and cheap looking. A bit of white plastic surrounding the panel of rear ports doesn't change that. Actually, it probably wouldn't hurt airflow to get rid of it.

It's not exactly bursting with features, either, though the price point makes that inevitable. Frills like LED debug displays, power and reset buttons, switches to toggle auto-overclocking – none of that appears. On the other hand, the Z170-A delivers pretty well on the stuff you actually need.

OVERCLOCKING PROWESS

Apart from all those USB ports, there's an M.2 slot for super-speedy SSDs with NVMe support. The PEG-16 graphics slots have support for both Nvidia SLI and AMD Crossfire multi-GPU graphics, too. Look even closer and you might spot the dedicated header for a CPU water pump, which is genuinely useful now that water cooling has become both mainstream and relatively affordable.

Chuck Asus's fantastic UEFI BIOS interface into the mix, then, and you have a strong all-round package, especially if you're the sort that tends to build a PC, close the door and just get on with it, rather than someone who likes to gaze lovingly at LED-lit innards through a window. That applies when you take performance into account, too.

At stock clocks, with an Intel Core i7-6700K on board, the Z170-A trades blows with MSI's much more expensive Z170 Gaming M7. It's millimetrically behind in Cinebench and x264 encoding, but marginally ahead in *Shadow of Mordor*.

Even more impressive, given the Z170-A's price point, is its overclocking prowess. It achieves exactly the same 4.7GHz overclock as the other Z170s we've seen, including MSI's Gaming M7. What's more, like every other board, that 4.7GHz can be achieved using either the 6700K's unlocked multiplier or via the baseclock.

With an unlocked chip like the 6700K, you may as well use the multiplier. But the baseclock performance bodes well for possible future Skylake processors that may come at lower price points. The age of clocking the twangers off a cheap CPU may be about to return. If it does, it makes sense to have a cheap motherboard capable of decent overclocks itself. The Asus Z170-A wouldn't be a bad choice. **–JEREMY LAIRD**

VERDICT 8

Asus Z170-A

+ STAR TREK Has at least one of everything you actually need; great all-round performance.

− GALAXY QUEST Little by way of fun features and frills; looks and feels as cheap as it is.

£117, www.overclockers.co.uk

SPECIFICATIONS

Chipset	Intel Z170
Socket	LGA1151
Form factor	ATX
Memory support	DDR4
Storage	6x SATA, 1x M.2, 1x SATA Express
USB	2x USB 2.0, 2x USB 3.0, 1x USB 3.1, 1x USB 3.1 Type-C

BENCHMARKS

	Asus Z170-A	MSI Z170A Gaming M7	Asus Z170 Pro Gaming
Cinebench R15 (index)	914	**915**	883
x264 HD video encoding (fps)	57	**58**	55
Memory bandwidth (GB/s)	**26**	**26**	**26**
Shadow of Mordor (min/avg fps)	**63 / 92**	62 / 91	57 / 92
Maximum multiplier OC (GHz)	**4.7**	**4.7**	**4.7**
Maximum base clock OC (GHz)	**4.7**	**4.7**	**4.7**
Cinebench R15 at max OC (index)	**1,012**	1,008	1,011

Best scores are bolded. All boards tested with an Intel Core i7-6700K and a Corsair Hydro H100i water cooler.

It looks cheap, it feels chintzy, but it's probably all you actually need.

MSI's Gaming M7 is a tasty-looking number.

MSI Z170A Gaming M7

An upmarket Z170 board for the well-heeled gamer

IT'S THE QUESTION that just won't die. And MSI's new Z170A Gaming M7 is going to have to answer it. Is there any point in spending more on an upmarket motherboard?

Not that the Gaming M7 is mega money. At £180, it's far from the most expensive board you can buy that's based on Intel's new Z170 chipset. Not with mobos priced beyond £400, like Gigabyte's bonkers GA-Z170X-Gaming G1, it ain't. But it's still £50 more than two Asus efforts we've seen, and £20 pricier than MSI's own Z170A Gaming M5. So it'll need to sing that little bit louder for its supper.

The good news is that, if aesthetics are near the top of your list, the M7 will be a winner well worth the extra wonga. It looks expensive. Part of that is the matte finish of the main PCB, which instantly separates it from the two Asus boards and their shiny cheapness. It's utterly superficial, but subjectively, it's the difference between something that feels like an escapee from a south-east Asian sweatshop and a more premium product.

Elsewhere, the LED debug display, power and reset switches, along with a knob for automated overclocking, add to the upscale vibe, as do the more generous component cooling and metal-clad PEG-16 graphics slots. We can't help but notice the extra SATA Express port compared to the Asus boards, too.

WORTH THE MONEY?

Irrelevant given SATA Express's DOA status? Probably. So, try this for size. The Gaming M7 has two M.2 slots. That's handy, and also raises the prospect of M.2 RAID arrays. Can you imagine the bandwidth bomb that could drop? We can. But sadly, imagining is all you can do, since this board doesn't support both M.2 slots running in PCIe mode at the same time. When installed, the second M.2 drive drops into SATA mode. Poo.

While we're talking big bandwidth, you also get both USB 3.1 and USB Type-C support. Like with all Z170 mobos, the USB situation is complicated, with the back panel offering three USB 2.0 ports, two USB 3.0, a standard USB 3.1 port and a new-fangled USB 3.1 Type-C port. Phew!

Elsewhere, you get the usual refinements, including properly isolated audio circuitry and military class five components, including titanium chokes and support for both Nvidia SLI and AMD Crossfire multi-GPU graphics setups.

Of all the added extras, then, it's arguably that Game Boost rotary knob that's most intriguing. The idea is you dial up the level of overclock you fancy, reboot, and, presto, easy idiot-proof overclocking up to 5GHz. It sounds ruddy marvellous, but in practice, it doesn't truly deliver.

To cut a long story short, the highest overclock we achieved with our i7-6700K, using the Game Boost dial, was an unspectacular 4.2GHz. That's the same as the 6700K Turbo mode – pretty lame.

The good news is that a quick trip into the BIOS will allow you to hit 4.7GHz with ease, which is as good as any other mobo will manage with this particular 6700K. The gaming M7 also knocks out some very nice numbers in our stock-clocked benchmarks across the entire rendering, video encoding and gaming gambit.

So, the M7 has no easy answers for that value conundrum. Like all premium boards, it can't fully justify its price in performance terms. But it's an appealing proposition. If we could afford it, we'd probably pull the trigger. –JEREMY LAIRD

VERDICT 8 **MSI Z170 Gaming M7**

⊞ **QUAKE III** Fantastic feature set; looks like a quality item; great all-round performance.

⊟ **DOOM III** Difficult to fully justify the price; auto-overclocking feature is a definite dud.

£180, www.scan.co.uk

BENCHMARKS

	MSI Z170A Gaming M7	Asus Z170 Pro Gaming	Asus Z170-A
Cinebench R15 (index)	**915**	883	914
x264 HD video encoding (fps)	**58**	55	57
Memory bandwidth (GB/s)	**26**	**26**	**26**
Shadow of Mordor (min/avg fps)	62 / 91	57 / 92	**63 / 92**
Maximum multiplier overclock (GHz)	**4.7**	**4.7**	**4.7**
Maximum base clock overclock (GHz)	**4.7**	**4.7**	**4.7**
Cinebench R15 at max overclock (index)	1,008	1,011	**1,012**

Best scores are bolded. All boards tested with an Intel Core i7-6700K and a Corsair Hydro H100i water cooler.

SPECIFICATIONS

Chipset	Intel Z170
Socket	LGA1151
Form factor	ATX
Memory support	DDR4
Storage	6x SATA, 2x M.2, 2x SATA Express
USB	3x USB 2.0, 2x USB 3.0, 1x USB 3.1, 1x USB 3.1 Type-C

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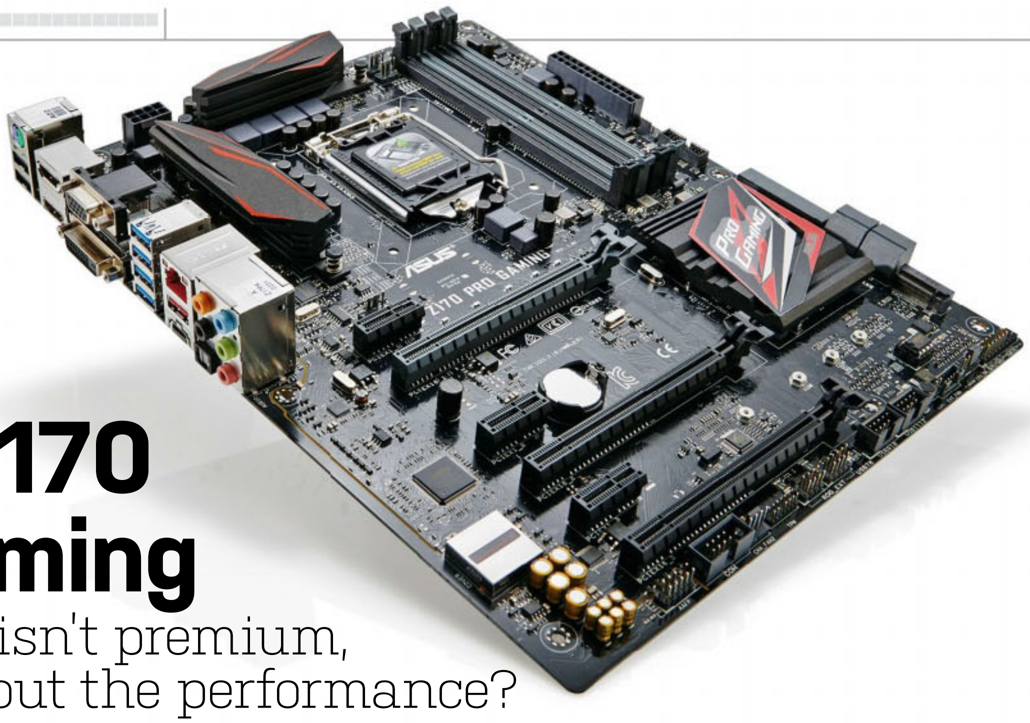
The red-'n'-black styling is standard gaming fare.



Asus Z170 Pro Gaming

The pricing isn't premium, but what about the performance?

THAT GAMER 'LOOK' and great performance, but without the usual premium pricing. That's the proposition-going-on-sales-pitch for Asus's new Z170 Pro Gaming. It's the affordable option for performance freaks. Of course, you could also say this ain't no Asus ROG or TUF board. It's a poverty-spec item you'd only buy if you can't afford something better. So which is it, Barry bargain or false economy?

For now, we can't provide a complete answer. It's early days for both the new Intel Z170 chipset and the snazzy Skylake processors that slot into it. So, it'll take time to shake out exactly what you can expect from the platform as a whole, and motherboards and CPUs in particular.

What's more, we haven't had a chance to take Asus's higher-end Z170 boards for a spin yet. That said, we do have an MSI Z170A Gaming M7 on hand to provide some higher-priced context (see page 28). But before we deep dive into those performance comparatives, let's take a closer look at the Pro Gaming board.

You certainly wouldn't mistake it for a high-end board. Thin and shiny, the PCB is just a little too skanky. That said, the red-'n'-black styling cues do provide a whiff of gaming pizzazz. Because, ya know, red-'n'-black means gaming. Handily, the cooler for the PCH chip has "Pro Gaming" writ large across its torso.

If you're obsessed with bandwidth, the other items you'll pick out pronto start with the PCI Express port. Yup, just one, which is probably fine given you can't actually buy a PCIe SSD. The standard seems to be stillborn. Instead, it's the M.2 interface that's become the default option for really fast storage. The Pro Gaming does indeed serve up just the one M.2 slot, but few mobos do better than that. The good news is that the slot is the fully four-lane PCIe 3.0 Monty, and also supports all available lengths of M.2 SSDs. Yay.

FRILLS APLENTY

Then there's the USB connectivity. First, you get a pair of USB 2.0 ports. Then there are a quartet of blue-tinged USB 3.0 sockets. The real fanciness involves the red USB 3.1 port and the puny little USB 3.1 Type-C socket below it, both courtesy of an ASMedia ASM1142 controller. This board has all your USB bases covered – even if you only get one each of the newbies.

Get a bit more forensic and you'll pick out one or two further frills. There's a 10-phase power supply for the CPU socket, which is welcome given the changes in overclocking setup for Skylake CPUs. Or perhaps you'll spot that the SupremeFX audio circuitry is properly shielded to prevent all those annoying pops.

Actually, fire her up and what you're presented with is the same slick UEFI BIOS interface that's seen across all kinds of Asus boards of late. What you don't get is frills like an LED debug read out, or hardware buttons for functions like power, reset and auto-overclocking.

Not a bad package then. But do you lose anything when it comes to performance? The evidence regarding overclocking suggests no. You could stamp all over a cigarette paper with boots and you'd still struggle to slip it between this and the other Z170s we've tested. Stock-clocked performance is another matter, with the Pro Gaming bringing up the rear. That's despite using the latest BIOS update.

We suspect future updates will close the gap. But as things stand, the Pro Gaming's performance report card is just a tiny bit untidy. –JEREMY LAIRD

BENCHMARKS

	Asus Z170 Pro Gaming	Asus Z170-A	MSI Z170A Gaming M7
Cinebench R15 (index)	**883**	914	**915**
x264 HD video encoding (fps)	55	57	**58**
Memory bandwidth (GB/s)	**26**	**26**	**26**
Shadow of Mordor (min/avg fps)	57 / 92	**63 / 92**	62 / 91
Maximum multiplier overclock (GHz)	**4.7**	**4.7**	**4.7**
Maximum baseclock overclock (GHz)	**4.7**	**4.7**	**4.7**
Cinebench R15 at max overclock (index)	1,011	**1,012**	1,008

Best scores are bolded. All boards tested with an Intel Core i7-6700K and a Corsair Hydro H100i water cooler.

VERDICT
7

Asus Z170 Pro Gaming

⊞ **GAMER** Ticks all the important spec boxes; overclocks as well as anything else.

⊟ **LAMER** Looks pretty cheap; stock-clocked performance is a tiny bit disappointing.

£124, www.novatech.co.uk

SPECIFICATIONS

Chipset	Intel Z170
Socket	LGA1151
Form factor	ATX
Memory support	DDR4
Storage	6x SATA, 1x M.2, 2x SATA Express
USB	2x USB 2.0, 4x USB 3.0, 1x USB 3.1, 1x USB 3.1 Type-C

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This chassis looks all too familiar, but it's a stunning build nonetheless.

Z170 SERIES
ASUS
Z170-A
msi
NZXT.

Cyberpower Infinity X77 Pro GT

Skylake is here! Look busy

OKAY, WE ALL KNOW why you're here. This is the first PC we've seen containing Skylake Core-i7. It's the machine we managed to get our hands on to review, and all in all, it's the first build that's blown us away for compute performance in a long while.

So, what is it that Cyberpower has brought to the table? Well for £1,499 (including VAT and delivery), you get yourself an Intel Core i7-6700K overclocked to a cushy 4.5GHz, sitting snuggly on an Asus Z170-A motherboard, with 16GB of Kingston HyperX memory and a GeForce GTX 980 graphics card.

Still, we all enjoy a good tease, so we're going to start with the chassis. Just to annoy you. The NZXT Noctis 450 tower chassis is a well-built, well-rounded gaming tower. It's a little more audacious than it's more-sophisticated H440 sibling, but it still contains all of the original interior layout that came with its predecessor. With one added benefit – easier access to airflow. The half-mesh, half-stylish panel helps provide the three 120mm front intake fans with more than enough air to keep your rig as cool as it can be. Additionally, the top panel allows for better access for your exhaust fans to pump out all of the hot air being generated by your brand new shiny CPU, that we're totally getting around to, don't worry!

DAMNING THE DEVIL

The Corsair Hydro H100 is a bit of an odd one. It's not the i-series, nor is it any of the older revisions of Corsair's most famous cooler. Think of it as a 240mm all-in-one, without the glitzy LEDs in the middle, or Corsair Link enabled. Sounds simple, but it gets the job done. And it comes with a fan controller, and some holes for external radiator mountings, and a couple of cable ties from the accessory kit.

Okay! Fine. Let's get to it. Skylake is in, and wow, is it a monster. We're talking a good 10 per cent increased performance over the last generation of CPU (Devil's Canyon) in computational tasks, and anywhere between 20–40 per cent more graphical horsepower for integrated gaming operations. But heh, who cares? It's got a GTX 980, why are we interested in integrated? To put it simply, with DirectX 12 being introduced with Windows 10, it's now going to be possible to leverage that graphical processing power to synergise with your dedicated graphics card, improving in-game performance. And although we won't see any huge improvements until DX12 games start hitting the shelves, this should be something we can utilise straight out of the gate, with a potential 6–12fps boost on average rates in most of your gaming scenarios. Sounds jazzy, right? We'll keep you informed as details emerge.

So, should you buy this rig? If you don't have a solid gaming PC, or you feel like it's time for a dependable upgrade, this is a fantastic solution. Want to get into Twitch and game streaming? Easy as. Looking to render some YouTube videos? Sorted. Wanting to game at 1440p comfortably? Not a problem. Hell, if you really wanted to, you could even throw in another GTX 980 just to push that frame buffer ever higher. But the big question is the price.

From our calculations, you're paying a £150 premium up front for this build. But Cyberpower covers you with a three-year limited warranty, and it's nicely put together, even coming with a 500GB SSD and a free copy of Windows 10. **–ZAK STOREY**

VERDICT
8

Cyberpower Infinity X77 Pro GT

+ **SKYFALL** Brand new spec; good power to price ratio; solid computational rig; great for streaming.

− **A VIEW TO A KILL** £150 premium; red LEDs on chassis clash with white; cooler isn't a H100i; reference GTX 980.

£1,499, www.cyberpowersystem.co.uk

SPECIFICATIONS

CPU	Intel Core i7-6700K @4.5GHz
Motherboard	Asus Z170-A
Memory	Kingston HyperX Fury DDR4 16GB (4x 4GB) @2,400MHz
Graphics	MSI GeForce GTX 980 Gaming
Storage	Samsung 850 EVO 500GB SSD; 2TB 7,200RPM HDD
Case	NZXT Noctis 450
Power supply	Corsair 600W (Gold)
Warranty	Three-year limited

BENCHMARKS

	Cyberpower Skylake PC	Box Cube Pro Forma
Cinebench R15	**986**	930
PCMark 8	**4,521**	4,229
Bioshock Infinite	21 / 112	**52 / 102**
Total War: Attila	**13 / 21**	13 / 19
Shadow of Mordor	**35 / 58**	37 / 47
3DMark: FireStrike Extreme	**6,008**	5,295
Price	£1,499	£1,400

Best scores are bolded. Game results are min/avg fps. All tests run at 1440p at Max and 4x AA where possible.

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PC Specialist Vortex S

How do you like your Skylake in the morning? How about with an i5?

PC SPECIALIST CAME TO US this month with a prebuilt PC we just couldn't refuse. An NZXT Source 340 infused with Intel's latest Core i5-6600K, 8GB of DDR4, a 240GB SSD and a wee little Zotac GeForce GTX 960 4GB card to top it all off. How could we say no?

The machine comes packaged inside the NZXT Source 340, a more budget-oriented chassis from the American manufacturer. Priced at around £60, the case isn't abundantly covered in the features seen in the dearer H440 or Noctis line, yet it's still a fabulous thing. Why? It looks gorgeous. The soft-touch panels situated everywhere (even the interior) are a sensation for the senses, with an almost satin look and feel to them. The design is bold and precise, very simple with a square-based aesthetic. Sounds dull, but it screams sophistication.

For those of us who are little older, and beyond the days of cases shouting at us with pointy bits and redness, this chassis is incredibly tidy. Cooling options are quite limited, mostly due to the size and design of the chassis. The front supports two 140mm fans – ample space for an NZXT Kraken X61, for example – with the roof supporting an additional 140mm fan. And then, of course, there's space for a 120mm in the rear.

PC Specialist has opted to go for two exhausts (both top and rear) and has included a Cooler Master Hyper 212 Evo to cool that Core i5-6600K. But considering this build is on such a tight budget, we can see why this has been done. Equally, if you've got a bit of extra coin kicking about later, the Source 340 is very easy to work in, so you shouldn't have any trouble throwing in two fans at the front of the chassis.

MAXIMUM VALUE

Let's cut to the chase. What we're all interested in here is how this bad boy performs. Intel's Core i5 line of processors has always been the one that gamers gravitate towards. Packing four of Intel's solidly engineered computational cores, minus the Hyperthreading (often seen as unnecessary to the modern gamer), and a little less cache, it's easily been more than enough for any of today's modern games. This particular rig is no exception. Although Intel's graphics drivers aren't quite there yet, we managed some impressive benchmarks across the board. Our average frame rate in *Bioshock* was 100-plus at 1080p, and most of the other games we benched were well above the 30fps mark. All the games were tested at the absolute maximum possible settings, with none of the hardware overclocked. All in all, it's another solid offering from Intel.

Bang for your buck is the most important aspect of any build like this, and you're not going to beat PC Specialist when it comes to pricing up a similar build. Our pricing came out at around £807. Not much more, but once you tie in building time, stress testing and general troubleshooting, you soon realise you're way over PC Specialist's budget. That being said, if you're looking for graphical performance, and that alone, you could get more for less by going with a similarly priced AMD GPU. For expandability, a cooler, quieter build and future upgradability, however, this rig wins hands down. **–ZAK STOREY**

VERDICT **8**

PC Specialist Vortex S

+ MAELSTROM Great build quality; looks fantastic; quick; future expandability; good performance.

– BATHTUB AMD outperforms graphically; lacking airflow support; small premium over AMD.

£799, www.pcspecialist.co.uk

SPECIFICATIONS

CPU	Intel Core i5-6600K @3.5GHz (Turbo to 3.9GHz)
Motherboard	Asus Z170 Pro Gaming
Memory	Kingston HyperX Fury DDR4 8GB (1x 8GB) @2,400MHz
Graphics	Zotac GeForce GTX 960
Storage	Kingston Savage 240GB SSD; 1TB 7,200RPM HDD
Case	NZXT Source 340
Power supply	Corsair VS 550W 80+
Warranty	Three-year standard

BENCHMARKS

	PC Specialist Vortex S	Aria Gladiator Fraction	AMD build from PCF 308*
Cinebench R15 (index)	**602**	581	507
PCMark 8 (index)	**3,645**	2,839	2,665
Bioshock Infinite	**45 / 69**	10 / 91	7 / 71
Total War: Attila	6 / 11	**17 / 26**	1 / 24 (DNC)**
Shadow of Mordor	23 / 28	**32 / 58**	7 / 24
3D Mark: FireStrike Extreme (index)	3,253	**5,230**	3,943
Price	£799	£1,075	£540

Best scores are bolded. Game scores are minimum/average fps at 1440p. *Rig from "Build a Budget Windows 10 PC" feature, September issue, which excludes an OS. **Did not complete without downgrading graphics.

4:08
12
GIGABYTE
P55

Gigabyte's new gaming lappie packs both Intel Broadwell and Nvidia Maxwell tech.

Gigabyte P55K V4

Two chips. One laptop. What's that remind us of…

OKAY, MAYBE NOT. But the Gigabyte P55K in this revised v4 format does come with plenty of interesting newness. Don't let its familiar threads fool you. For starters, the fancy Core i7-5700HQ CPU debuts Intel's new Broadwell architecture in quad-core format for laptops. In outright performance terms, it's not a dramatic step forward over older Haswell models.

It's a sweet chip with Hyperthreading and a top Turbo speed of 3.5GHz. It's just not going to rock your world if you've experienced a Haswell mobile quad. Well, apart from battery life. Your mileage will vary depending on usage, but our testing suggests you get up to five hours HD video playback in flight mode. That's pretty bloody solid for a 15.6-inch gaming laptop.

The P55K's other intrigue involves its graphics chip, the nifty new Nvidia GTX 965M. Right away, you should be wondering exactly what GTX 965M means. There is no GTX 965 desktop card, just 960 and then 970. Fire up GPU-Z and the first numbers you'll spot are the 1,024 CUDA cores and 128-bit memory bus. Ah, it'll be a GM 207 chip as per the GTX 960, then.

But hang on. GPU-Z also shows a GM 204 chip ticking away. That's the much bigger beast that powers the GTX 970 and 980 desktop boards. Long story short, the 965M is a GM 204 chip with half of the good bits turned off. Why not just use the GM 207 chip? Who knows or really cares.

As it happens, the 965M chip makes for a nice match with the P55K's rather lovely 1080p LCD panel. As our benchmarks show, at native res and maxed out, most games are pretty playable. That applies even to *Shadow of Mordor* with its über-textures enabled. You're still looking at average frame rates in the 30s. Wind back on just a few settings for serious smoothness. The bad news involves noise. The P55K is a whiney little bitch under full gaming load.

SMOOTH OPERATOR

While we're talking graphics, what about mobile G-Sync? That's Nvidia's game-smoothing tech that syncs graphics output with display refresh rates. For G-Sync to be functional in a laptop system, you need the Nvidia graphics directly connected to the laptop's LCD panel via embedded DisplayPort. This immediately throws up an incompatibility with Nvidia's Optimus tech, which routes the discrete GPU's output through the Intel-integrated video port. And thus, no direct connection twixt Nvidia graphics and the panel. The P55K does indeed implement Optimus. And thus our take is that you'll likely never be able to switch on G-Sync.

As for the rest of the P55K, it's a pretty nice portable. The chassis sports some really nice plastics. Of course, they're still plastics. The likes of a MacBook have nothing to fear. Still, the keyboard is seriously slick, free from flex and deftly backlit. Even better, however, is the LCD display. It's a wide-angle IPS effort with a 1080p native and it's absolutely glorious. Games, movies and even the Windows desktop look gorgeous.

If we're being really picky, we'd say the mSATA Liteon SSD is a bit disappointing given the advantages of the latest M.2 drives. And at 128GB, it's not exactly huge, even if there's a 1TB magnetic drive to back it up. But the fact that all of this is yours for around the £1,000 mark means we're willing to allow a little leeway. It's a very appealing all-round package and a lovely little gaming portable. **–JEREMY LAIRD**

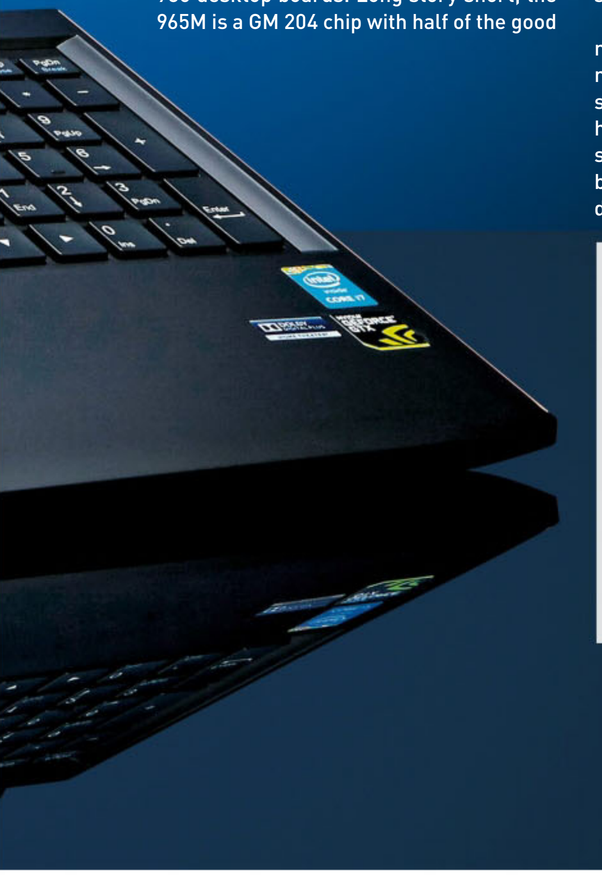
VERDICT 9

Gigabyte P55K v4

+ FINE WINE Fancy new Broadwell CPU; nice graphics performance; good battery life.

− AWFUL WHINE CPU not a huge performance bump; Nvidia's G-Sync tech probably not an option. Loud.

£999, uk.gigabyte.com



SPECIFICATIONS

CPU	Intel Core i7-5700HQ
GPU	Nvidia GeForce GTX 965M
RAM	8GB DDR3
Screen	15.6-inch, IPS, 1920 x 1080
Chipset	Intel HM97
Storage	128GB mSATA SSD, 1TB HDD
Weight	2.5kg

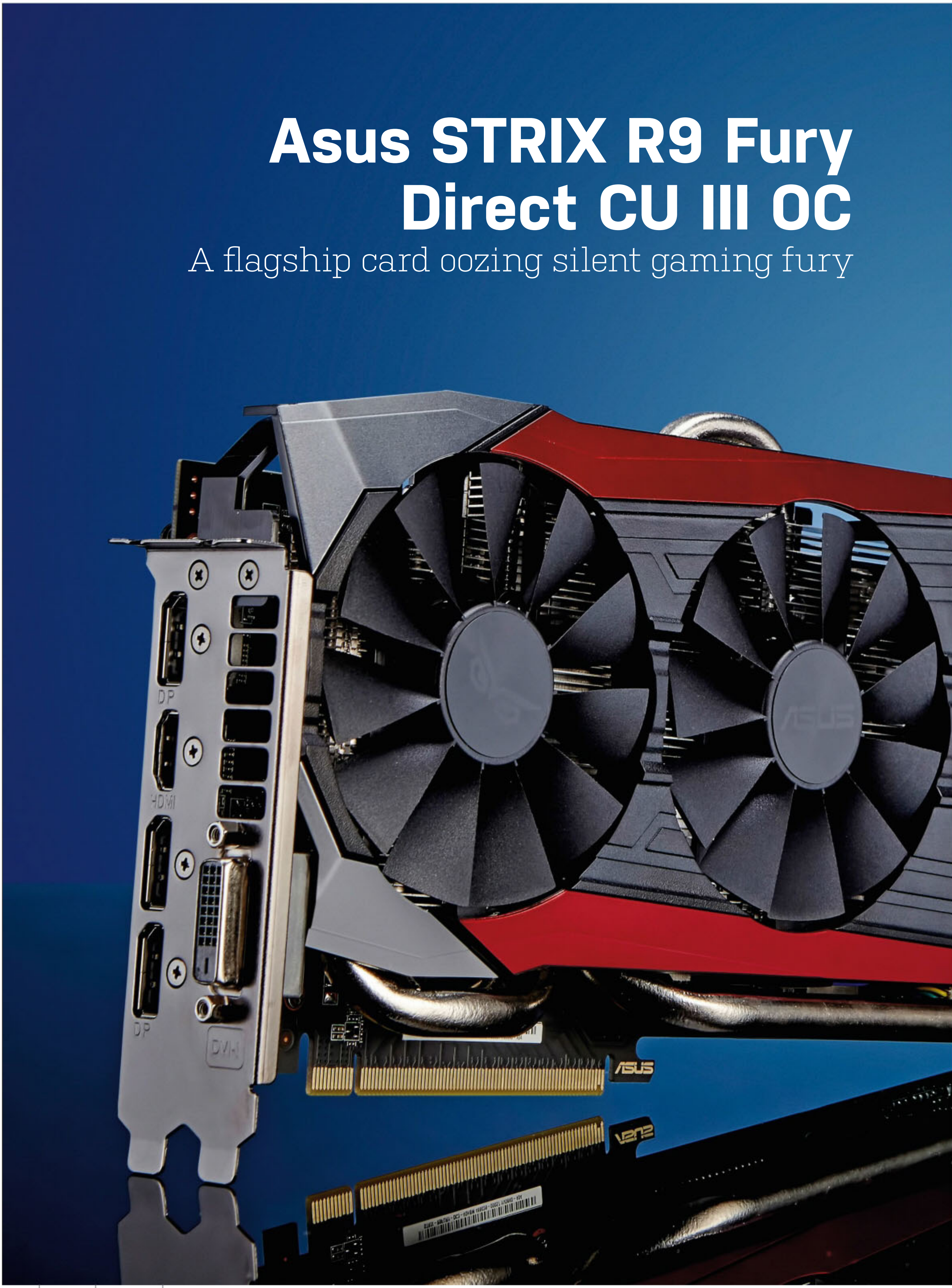
BENCHMARKS

	Gigabyte P55K v4	Gigabyte P35K v3	Asus N550JV
Bioshock Infinite (min/avg fps)	10 / 52	**13 / 52**	10 / 51
Shadow of Mordor (min/avg fps)	14 / 35	**22 / 53**	12 / 33
Metro: Last Light (min/avg fps)	**14 / 23**	3 / 23	6 / 23
Heaven (min/avg fps)	**7 / 30**	7 / 27	7 / 29
CineBench 15 (index)	**675**	658	573

Best scores are bolded. All tests run at each laptop's native resolution.

Asus STRIX R9 Fury Direct CU III OC

A flagship card oozing silent gaming fury


DP
HDMI
DP
DP
DVI
ASUS

AMD HAS FALLEN SHORT in the last month. With many of us hoping the red team would finally pull back a win from the boys in green, it was with disappointment that we witnessed those Fury X benchmarks come through. All in all, the battle seemed lost. The war was over. Until now.

The standard Fury is a different beast entirely. Although being the little brother to the Fury X, and still housing the same memory and GCN architecture setup, there's one major difference between the two – AMD doesn't make these cards. Which is why we've arrived here, the Asus STRIX R9 Fury Direct CU III overclocked edition. Coming in at an impressive 1,020MHz overclock, 30MHz less than the Fury X, this card features 500-odd less stream processors than its disappointing big brother. However, if the GTX 980 Ti taught us anything, it's that having less CUDA cores or stream processors doesn't necessarily take you out of the running.

But let's talk about the card itself. Asus is one of the first companies to take on the challenge of fully automating its PCB production line. The entire card – from chip and memory, to board and capacitors – is built by robots. Fortunately, this hasn't drastically upped its price. Even though the new technologies have cost Asus an arm and a leg to develop, the reduction in labour costs are equally significant. What this means for us end users is no more soldering, no more flux and no more sharp bumps. The level of reliability and quality control is fantastic, beyond anything so far in the graphics card industry.

THE TRIPLE THREAT

That's all good and dandy, but how does the card actually perform, right? The DC III has been under request for years, and for cooling capacity, the Strix does not disappoint. Providing three 92mm fans to cool two exclusive 10mm direct GPU contacting heat-pipes, this card has phenomenal GPU-chilling potential.

What Asus has done here, however, is analyse how this cooling is applied. Instead of trying to keep the card below 30–40°C at all times, it's worked on making sure noise control is the top priority. Each fan runs independently on a 0dB fan curve, as has become quite common recently. However, unlike the vast majority of the competition's solutions, this 0dB technology is embedded into GPU load, as opposed to temperature. What this ensures is that as soon as you're out of game, your card isn't creating any unnecessary noise to cool down a GPU that can gently ramp down anyway. This is a card that, at max, spins at 40 per cent. Even then it's barely audible, even on our open test bed. Impressive, to say the least.

When it comes to performance, this is where Asus and AMD to some extent blew us away. For a card that comes in to the market at roughly £450, it performs incredibly well. Overclocking, we managed to push the core clock up another 100MHz over stock (70MHz over Asus's stock settings). Yet even as we dialled back for our benchmarking process, the scores were still only a few frames per second behind that of the Fury X. This was something we utilised GPU Tweak II to achieve, as Asus has allowed access to the power limit feature within the card. It's worth noting, however, that High Bandwidth Memory (HBM) still doesn't overclock at all.

All in all, this card is brimming with neat features, it looks stunning, and it performs almost as well as AMD's flagship for a price comparable to a GTX 980. What Asus has put together is a phenomenal bit of hardware, and we're going to be sad to see it leave. –**ZAK STOREY**

VERDICT 9

Asus STRIX R9 Fury Direct CU III OC

FURIOSO Stunning build quality; impressive cooling design; strong performance; great price.

ESTINTO It's very tall; backplate doesn't cover the GPU.

£456, www.overclockers.co.uk

SPECIFICATIONS

GPU	AMD Fury
Stream processors	3,584
Texture units	224
ROPs	64
Transistors	8.9 billion
Memory capacity	4,096MB HBM
TDP	275W
Connectivity	3x DisplayPort, 1x HDMI, 1x DVI-I

BENCHMARKS

	Asus STRIX Fury DC III	AMD Radeon Fury X	Nvidia GeForce GTX 980
Total War: Attila	18 / 26	19 / 27	**24 / 32**
Project Cars	45 / 52	49 / 57	**52 / 58**
Witcher 3: The Wild Hunt	**46 / 51**	44 / 50	41 / 48
Shadow of Mordor	34 / 62	29 / 66	**47 / 62**
3DMark: FireStrike Extreme	6,909	**7,415**	6,345
FurMark stress test (°C)	70	**50**	79

Best scores are bolded. Game results are minimum/average fps at 1440p.

After years of waiting, Asus fans finally have their triple fan cooler.

Cooling potential to knock your socks off.

ZOTAC
ZOTAC
16235-6
251-20923-4300F
B0235

Zotac GeForce GTX 980 Ti Arctic Storm

A low-temp, low-noise, beauty

AT THIS POINT, we're probably all aware of the power wielded by the GTX 980 Ti. It's a graphics processor sitting somewhere between polygon perfection and a trip to your local loan shark. Granted, it's quite a bit cheaper than a Titan X, and contains only half the memory and a couple of hundred fewer CUDA cores. Yet, with a kick in the overclocking chops, it'll easily keep pace, if not outperform that juggernaut when push comes to shove. So what gives? Why are we looking at this card again? After all, it's already in this month's group test.

Simply put, we were presented with a card that defies all logic and reason. Zotac's Arctic Storm edition is a fascinating take on a concept as old as custom PCs – effective cooling. The card packs three 92mm fans on top of a full-cover copper waterblock. What does this mean? Two things. Firstly, it's a card that can be run straight out of the box. You don't need a water-cooled rig to utilise the 980 Ti's powerful frame-wrenching abilities. Secondly, if you're willing to toy with water-cooling loops, this beastie can become a silent but violent solution to all of your graphical woes.

As for performance, this card is nothing short of unstoppable. It overclocks like a monster (mostly thanks to Maxwell's crazy GPU architecture). Even at stock, the frame rates will satisfy the most avid 1440p gamer. If you do delve into the realm of water and electricity, however, you'll find the card will run at around 29°C at idle and roughly 50°C at load – a whole 30°C lower than purely using the stock cooler. Generally, this'll lead to the 0dB fan tech kicking in, allowing the card to turn deafly silent, even while gaming. However, what we found best was to actually keep the fans running at a constant 40 per cent power. This way the water block acts in conjunction with the heat-pipes and fans to create a mini radiator buried in the middle of your chassis, meaning you can decrease the overall temperature of your water-cooled rig and CPU temps in the process.

ROOM FOR IMPROVEMENT

Zotac's crazy solution doesn't come without its flaws. The barbs fittings are less than to be desired. We've been told you can reorient them, but we didn't manage it with all of the strength and tools in the office. And it'll also void your warranty, as you can possibly damage the o-rings on the fittings. Secondly, those barbs stop you from utilising any hard tubing, a recent trend in the water-cooling community. With simple G1/4 mounting points instead, this card might be nigh on perfect.

Concerning performance, you don't get much more from it when it's under water, as the cooling solution is already more than enough. At most, you'll gain around 20–30MHz on the core clock. An increase, but nothing to shout about. Ultimately, this card comes down to noise and flexibility. If you already have a custom loop, throw this GPU in. If you're just interested in running it on air, you can do that, too. Want a silent gaming machine? Sure thing. Want it even cooler than that? No problem. The possibilities are endless. There are concerns, especially if you're looking to run two in SLI and water, or with the orientation of the barbs, but it's still an outstanding graphics-rendering monster. **–ZAK STOREY**

VERDICT **9**

Zotac GeForce GTX 980 Ti Arctic Storm

+ CAFFÈ LATTE Insane performance; cheaper than a Titan X; looks good; flexible cooling potential; great for 1440p gaming; scales well in SLI.

− INSTANT COFFEE Difficult to orient barbs; still pricey; GPU isn't bin sorted.

£650, www.overclockers.co.uk

BENCHMARKS

	Zotac GeForce GTX 980 Ti Arctic Storm (SLI)	Zotac GeForce GTX 980 Ti Arctic Storm (water-cooled)	Nvidia GeForce GTX 980
Total War: Attila	18 / 50	**34 / 48**	29 / 39
Project Cars	**90 / 93**	64 / 70	52 / 58
Witcher 3: The Wild Hunt	**78 / 86**	59 / 66	41 / 48
Shadow of Mordor	**71 / 143**	17 / 76	23 / 51
3DMark: FireStrike Extreme	**13,686**	8,461	6,345
Heaven	**37 / 143**	17 / 76	23 / 51
FurMark stress test (°C)	81	**52**	79

Best scores are bolded. Game results are minimum/average fps at 1440p.

SPECIFICATIONS

GPU	GM 200 Maxwell
CUDA cores	2,816
ROPs	96
Transistors	8 billion
Memory capacity	6,144MB
TDP	250W
Connectivity	3x DisplayPort, 1x HDMI, 1x DVI-I

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That shiny, plasticky chassis wouldn't be an issue for a second were we looking at a larger panel.

Viewsonic VX2475Smhl-4K

What's a few inches between friends?

THIS WHOLE 4K THING is all about compromises right now. Forgetting the fact that running games at the mighty 3840 x 2160 native resolution of 4K monitors is incredibly demanding on your graphics hardware, just trying to find the right monitor in the first place can be incredibly tough.

The first 4K panel we checked out was a frighteningly expensive £3,500 Asus 32-inch IGZO panel; great-looking but wallet-destroying. From there it was either weaker panel tech in TN trim for the larger screen sizes, or too-expensive IPS technology. Or you could compromise and go for a smaller screen space paired with a finer panel. This is the route Viewsonic has taken with its latest 4K monitor.

Matching Samsung's PLS panel technology (IPS by any other name would smell as sweet…) with a 24-inch screen size means Viewsonic can offer lovely-looking image fidelity for around £300. In 4K terms, that's a bit of a bargain.

Pretty much any other 4K panel you'd care to mention at that price will be resolutely TN. Not that today's twisted nematic tech is as bad as the old days – both the colour reproduction and viewing angles are much improved – but it's still nowhere near the image quality you'll get from a bona fide IPS screen. And the oh-so-similar PLS technology technology in this Viewsonic panel is top-end 8-bit style, so it's rocking 16.7 million colours and full sRGB colour depth.

The white reproduction on this screen then is pretty much immaculate, and the contrast levels typically excellent. As is the way with this sort of panel tech, however, the black levels aren't quite up there with the depth you'd get from an MVA screen like the lovely and large Philips BDM4065UC. But when you're talking about colour reproduction and viewing angles, the Viewsonic's got it. So, all is rosy then, right?

THE SCALING SITUATION

Were this monitor just a little bigger – say, 27-inch – we'd be all over this screen. With a quality display, we'd say 27-inch is about the minimum screen size you can really get away with for a 4K monitor. And even that is pushing it. You don't really get the same stunning effect that the extra pixel count has on image depth with a 27-inch panel that you do with something like that 40-inch Philips, let alone a 24-inch screen such as this Viewsonic.

At that size, you're simply not getting the most out of the 4K resolution when we're talking gaming. The incredible demands that native resolution makes upon your graphics card are only worth the GPU effort when you're really getting to see the full benefit from the extra texture detail. And on the desktop, the native font on a 24-inch display is eye-straining, to say the least.

Windows 10 has of course improved its scaling efforts, but you'll inevitably come across older software that simply doesn't work with the new UI scaling boost. We use FRAPS in hardware testing almost constantly, and if you ever try running that classic app on a scaled desktop, you'll see what we're talking about.

With a £340 price tag, we could've forgiven it the flimsy, plasticky chassis. There's no height adjustment or twisting here, this is a basic setup. Until you get to the inputs that is. Incongruously, this is the first panel we've had in that rocks the new HDMI 2.0 interface, which will support the 4K resolution over HDMI at 60Hz for the first time, providing you've got a compatible GPU, anyways.

For just a few inches across the diagonal, we'd have a seriously impressive 4K package, then. Unfortunately, at 24 inches, the screen size is too small. It's just too big a compromise. –DAVE JAMES

VERDICT **8**

Viewsonic VX2475Smhl-4K

4K Great panel; decent price; HDMI 2.0.

NO WAY Screen size too small for 4K; plasticky chassis; limited adjustment.

£340, www.viewsoniceurope.com

SPECIFICATIONS

Screen size	24-inch
Native resolution	3840 x 2160
Panel technology	PLS
Response rate	2ms (GtG)
Connections	HDMI 2.0, DisplayPort 1.2a, MHL 2.0

Netgear PLP1200 Gigabit Passthrough Powerline Kit

A passthrough Powerline kit to deliver 4K around your house

POWERLINE ADAPTORS aren't the sexiest gear on the PC World shop floor, but they're selling by the bucketload. A big reason for that is smart TVs. But they also solve a couple of other problems. If you're lucky enough to live in a big house, they extend the reach of your network beyond normal bounds. And they can help with reliability in locations where too much network noise makes Wi-Fi flaky.

These adaptors conform to Homeplug AV2 (and backwards to Homeplug AV), which is a universal standard. If you have existing Powerline adaptors, you'll need to make sure they also conform to this standard. While it's perfectly possible to mix and match, we'd always recommend sticking to the same manufacturer. Up to 16 Homeplug AV or AV2 adaptors can be connected on the same network.

This set is fairly simple in that there's only one Ethernet port on each; Netgear doesn't currently do a 1,200Mb/s adaptor with extra ports, but this will surely come as it's already available on some of Netgear's own lower-speed adaptors, as well as on rival products from the likes of Devolo and TP-Link. Likewise, other adaptors are available with built-in Wi-Fi, though Netgear doesn't offer this yet. This is useful if you're extending your network to an entirely different part of the house, as you can create a new wireless network for devices in that area.

This Netgear set features passthrough, which means you can also plug something else in via the Powerline adaptor. It's useful if you don't have too many power sockets in your house – that predominantly means 1970s houses, which are too new to have been rewired, but too old to have enough sockets. You can plug an extension lead into this socket (you need to plug the Powerline adaptor directly into the wall for best results).

Status LEDs on the top-left of the kit show you the status of your connection. Red means the transfer speed is slow (under 50Mb/s), while amber and green mean the rates are better. We only experienced the red when we purposely plugged one of our adaptors into a multiplug extension. We don't recommend deploying any Powerline adaptors in this fashion, as there's so much noise and the transfer will be significantly slowed.

LIMITED OPTIONS

As with all such adaptors, setting up was remarkably simple. Just plug them into the wall where you want them and they'll automatically find each other. Although they're usually fairly speedy to locate other units, we were surprised at just how quickly these ones linked up.

Powerline communications are usually secure, in that only people inside your house have access to your power sockets. However, should you wish, you can create a secure Powerline network using the security buttons on the adaptors. Communications are then encrypted.

We weren't terrifically impressed with the speeds. Compared to the TP-Link AV1200 set, speeds were slower. The other thing counting against this Netgear set is the lack of extra ports on one of the adaptors. The cost of rival units with extra ports is only a few pounds more, while units with 802.11ac Wi-Fi are around the £100 mark. If you're extending the reach of your network, you need more options than just a single port.

With the rapidly growing number of devices in our homes comes the normal desire for Wi-Fi on the end of a Powerline extension. However, there is a market for products like this one if all you need to do is extend to a single desktop PC or smart TV, yet you still want a device that's going to be able to stream 4K. –DAN GRABHAM

VERDICT
7

Netgear PLP1200

⊞ **PREMIER LEAGUE** Decent price; reliable; passthrough very welcome; 4K no problem.

⊟ **SUNDAY LEAGUE** Performance isn't the best; Wi-Fi support would be better; only a single Ethernet port present.

£80, www.netgear.co.uk

BENCHMARKS

	Netgear PLP1200	TP-Link AV1200
Actual Mb/s	43.7 / 41.9 / 34.8	**177.8 / 72.4 / 61.1**
1.18GB file transfer (secs)	221 / 231 / 278	**57 / 140 / 166**

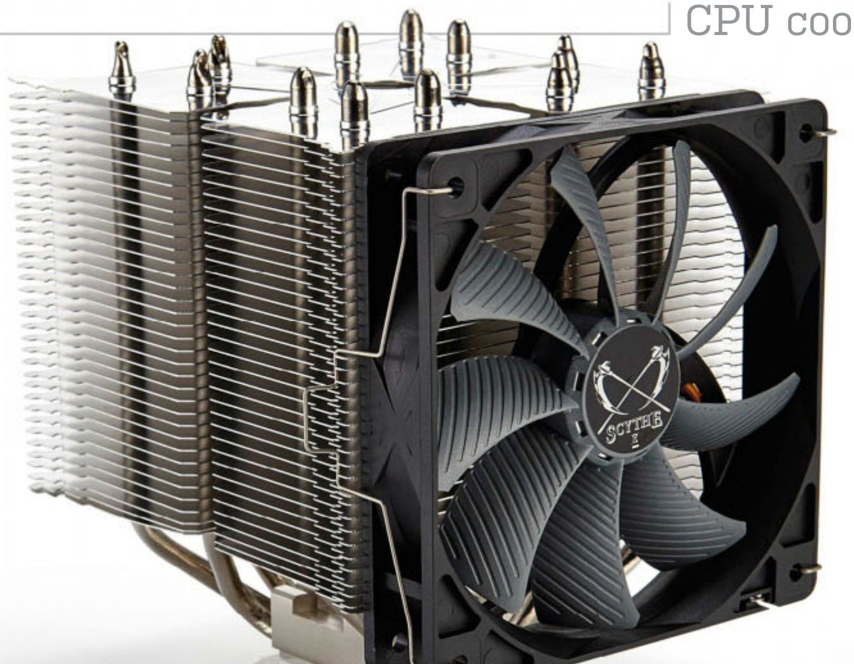
Best scores are bolded. Results are from tests carried out at close proximity (1m), from the other end of the house, and from the other end of the house in a noisy, multiplug environment.

SPECIFICATIONS

Standards	HomePlug AV2, HomePlug AV, HomePlug Green PHY, IEEE1901, IEEE802.3
Interfaces	Gigabit Ethernet Port, Power Socket
Plug	UK
Dimensions	120 x 58 x 42mm
Cables included	2x 2m Ethernet
Range	500m over electrical circuit
Cited speed	1,200Mb/s

Scythe Ninja 4

Stealthily lives up to its name


The new Ninja is a serious cooler for not much cash.

SCYTHE'S FOURTH-GEN flagship CPU cooler – successor to the highly successful Ninja 3 Rev. B – has just launched, and it's a bit of a whopper. But while measuring in at 130 x 130 x 155mm, and weighing 900g (with a fan), it still manages to be some 180g lighter than its predecessor.

New for this version is the cooling fin design, which Scythe is calling T-MAPS (Three-dimensional Multiple Airflow Pass-through Structure). It adds another pair of fins to the MAPS design of the Ninja 3, without adding to the weight of the heatsink. It's a neat trick, the design making it look like the fin unit is made up four separate stacks, with each aluminium fin around 0.4mm-thick and the matrix being made up of 36 of them.

The cooler uses six 6mm nickel-plated copper heat-pipes, which are U-shaped to give 12 heat flows, three per corner of the fin stack. These pipes are not in direct contact, but pass through the nickel-plated copper baseplate.

The Ninja 4 comes with a single Scythe GlideStream 120mm sleeve-bearing fan (4-pin PWM), which can fit on any of its four sides. To increase the cooling capacity, a second fan can also be fitted. That needs to be purchased separately, but Scythe does include an extra pair of wire-mounting clips in its box of bits. The fan spins between 300–1,500rpm, but has a handy speed controller built into one corner of the frame, giving three pre-set speed settings; High is 300–1,500 (29.5dBA maximum), Mid is 300–1,150 (23.5dBA maximum) and Low is 300–800 (12.5dBA maximum). Should you fancy doing away with the fan, the Ninja 4 is designed to take care of CPUs with a TDP of up to 53W passively.

Installing presents no real challenge at first, using Scythe's excellent Hyper Precision Mounting System (HPMS), which makes the job of organising the mobo baseplate and cooler mounts a doddle.

LOCKED AND LOADED

Extra brownie points to Scythe for supplying a long-reach screwdriver and a spanner in its box of bits – you can use either to tighten the cooler-mounting bracket screws. However, although that sounds easy, those with large fingers will soon be cursing while trying to hold the bracket screw and tighten it, especially if, like our Asus Z97 Deluxe mobo, the heatsinks are close to the CPU socket. The one blessing is that the cooler-mount has lugs that lock into the top of the baseplate, so at least you don't have to worry about it sliding all over the place as you lock the cooler into position on the HPMS.

And another thing. Because of the size of the cooler, memory modules with large heatsinks are a no-no if you want to mount the fan facing the memory slots. It covers the first two slots, so if you want to use the fan on this plane, low-profile memory is the way to go – there's 3cm of clearance.

The Ninja 4 performs very well, keeping our test Core i7-4770K (Asus Z97 Deluxe, 8GB DDR3-2133MHz) cool at stock speeds through all three fans settings, in both idle and 100 per cent peak modes. When the processor is overclocked to 4.5GHz, the cooler in low fan spin mode can cope at idle. However, when the chip is pushed to peak settings, the temperature rises alarming quickly to around 100°C, which is why we cut the test short.

Better news is that the Ninja 4 does at least return to the idle temperature of both the standard and overclocked speeds remarkably quickly, when it's no longer being pushed hard. The Ninja 4 also lives up to its name – it's extremely quiet in operation, even when being pushed throughout the three fan-speed settings. While the performance of the Ninja 4 is pretty impressive on its own, a quick glance at its price tag makes it all the more so. –SIMON CRISP

VERDICT 8 **Scythe Ninja 4**

+ SHINOBI Lighter than Ninja 3; good performance; quiet; price.

– COMMONER Fixing the cooler matrix to the mounts can be tricky; low fan speed can't handle overclocked CPU at peak.

£38, www.scythe-eu.com

BENCHMARKS

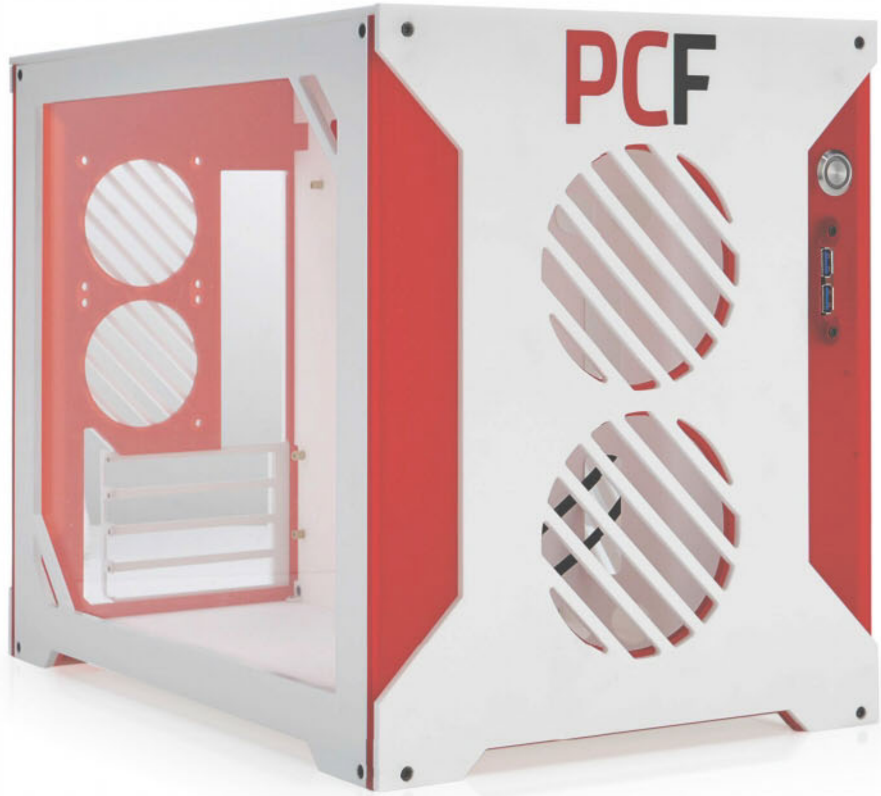
	Scythe Ninja 4 (high)	Scythe Mugen Max	Gelid SnowStorm
Idle temperature @ 3.5GHz(°C)	26	**24**	31
Peak temperature @ 3.5GHz (°C)	**55**	57	66
Peak-to-idle time @ 3.5GHz (sec)	**50**	134	87
Idle temperature @ 4.5GHz(°C)	27	**26**	47
Peak temperature @ 4.5GHz (°C)	76	**71**	n/a
Peak-to-idle time @ 4.5GHz (sec)	**55**	69	n/a

Best scores are bolded. Tested using an Intel Core i7-4770K and Windows 7 64-bit, all power saving turned off. Temperatures measured after 20 minutes using Prime 95.

SPECIFICATIONS

Form factor	Tower cooler
Dimensions & weight	130 x 130 x 155mm; 900g
Fan size	120mm 4-pin PWM
Heat-pipes	6x 6mm nickel-plated copper
Socket support	*Intel:* 775, 1150, 1155, 1156, 1366, 2011/ 2011v3 *AMD:* AM2, AM2+, AM3, AM3+, FM1, FM2, FM2+

Inlays, etchings, extensions? Parvum's got you covered.



Parvum S2.0

Ikea, eat your heart out. Flat-pack custom PCs for all!

WHAT CAN TWO guys operating out of a farm in Essex bring you? Well, some of the most custom-designed cases you can imagine, for starters. Parvum Systems is widely renowned for its stunning bespoke cases. Custom-built from the ground up for enthusiasts, its innovative designs come flat-packed, ready for assembly. The custom-cut acrylic panels comprise the exterior and interior of the chassis, allowing for a multitude of different layering effects and colours.

One of the options Parvum has among its entire range of cases is the ability to include acrylic inlaying. The bread and butter is simple. You send Parvum an inlay idea, via one of the approved file formats, and it'll inlay the design into the front panel or wherever you'd like, using what colours you'd like. As you can see, it can look pretty snazzy, especially if you have a sexy three-letter logo like we do.

It's a fairly painless affair when putting together your snazzy new case too, but you'll need a touch of patience, and it can take time to align all of the panels correctly. One thing you need to be wary of is how sharp the acrylic can be. It's quite possible to slice open your hand on a chassis during construction, only to be left limping around your keyboard, covered in tissue… we might be exaggerating a little perhaps, but you've been warned! There's not much you can do without sacrificing the clean look of the case, and to be fair, we'd rather keep it that way.

For cooling, this microATX chassis is well-endowed. You have room for two 120mm fans in the front, two 120mm fans in the roof and two extra 80mm fans in the back of the case. At least in the first half of this case. The S2.0 comes compartmentalised into two separate divisions, one to hold your power supply, cable mess and hard drives, the other to show off your clean and crisp build. But if that just doesn't sound like enough room to manoeuvre, Parvum will extend the chassis, allowing for three 120mm fans in the roof, as opposed to the regular two, for just £20 extra. Storage is provided with support for four 2.5-inch drives and an additional pair of 3.5-inch drives, all hidden away in the back of the case, hanging upside down from the roof.

MODDING HEAVEN

When it comes to building in the S2.0, the layout of the chassis and the smooth, curved design built into the motherboard tray really help keep the aesthetics clean and simple. Graphics card support can be a little limited – rather superb if you're running water-cooled graphical horsies or just a single GPU, but otherwise it can get a little cramped. Especially with blower-style card coolers. There just isn't enough room for two cards to breathe together in this case. But considering this is an incredibly feature-rich, compact microATX case, compromises have to be made somewhere.

Front I/O consists of an LED Dimas switch for power and reset, and two USB 3.0 ports. No inclusion of audio input or output means you do lose out on connectivity a smidge, but also avoid the extra clutter from not having that cable.

Investing in Parvum's S2.0 case is like walking into modding heaven. If you've an idea for a design, it can do it. If you're after a premium DIY case to house your new mATX monster, these boys have you covered! It's definitely worth looking into getting one of these beasties if you're interested in small form-factor builds.

This customisation does come at a cost, but when you consider the manufacturing process, materials and the time and effort Parvum puts into making these, it adds up to pretty decent value for money. The CaseLabs of the UK, home-brewed acrylic euphoria. –ZAK STOREY

VERDICT 9

Parvum S2.0 White/Red Case

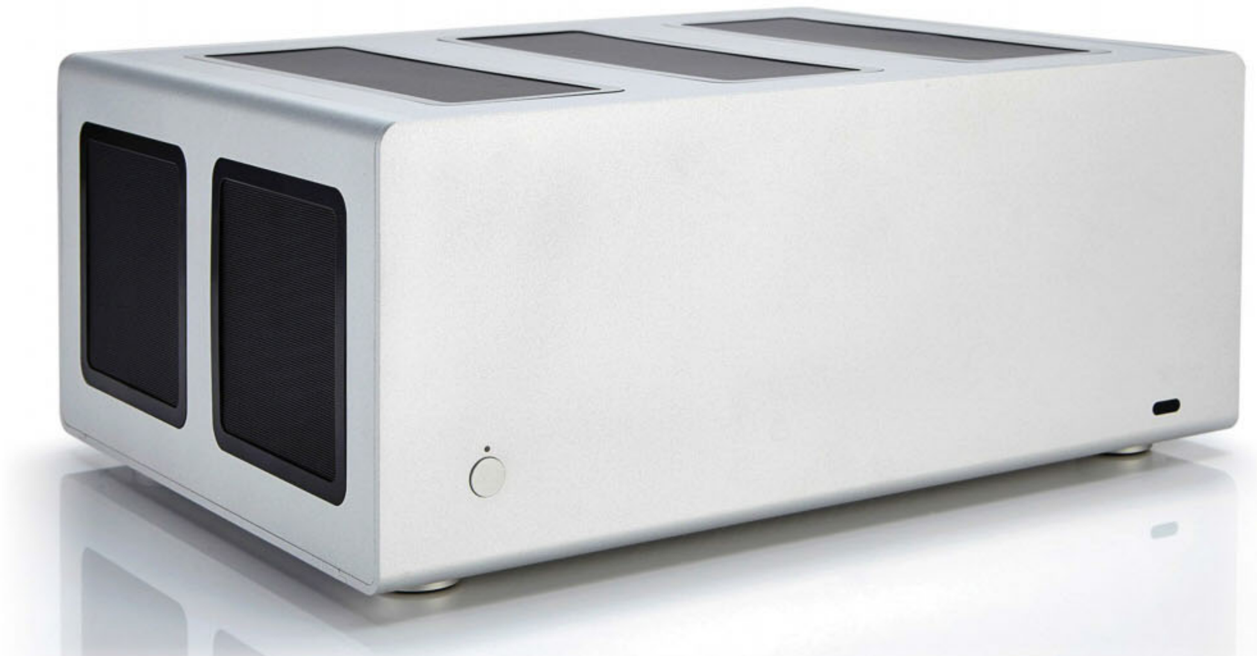
+ RAZOR EDGE Stunning design; cooling capacity; DIY case; modding potential.

− RUSTY SPOON Price; possible to cut yourself; white acrylic smudges easily.

£117, www.parvumsystems.com

SPECIFICATIONS

Form factor	mATX, ITX
Dimensions (W x H x D)	275 x 305 x 420mm
Cooling	*Front* 2x 120mm; *Top* 2x 120mm; *Rear* 3x 80mm
CPU cooler clearance	152mm
Storage support	2x 3.5-inch; 4x 2.5-inch



Superb build quality and an innovative internal design.

Streacom F12C

You could run out of ideas where to stick the fans and drives with this one

STREACOM MAY BE A NEW NAME to some, but the company with its head office in Holland and manufacturing plant in China has been around since 2010. It's made its name in SFF cases and passively cooled bits and pieces, which makes its latest product, the F12C, a bit of a departure, as it's been designed to support ATX motherboards.

So, it's a standard PC case then? Well, no. It just happens to be one of the most innovative cases we've seen for a long while. It's a desktop format case, ideal for building a serious home theatre PC, but oddly the case doesn't have any front I/O ports. In fact, it doesn't have an I/O panel full stop. There's nothing on the front bezel apart from the power button, power LED and the window for an IR unit. Streacom also has a weird take on what a thumbscrew is – what it calls thumbscrews are actually a pair of thumb wheels, which, after turning four or five times, release the lid.

Once you open it, the cleverness of the design takes a little while to sink in. With the lid removed, you're looking at an empty box. There are no drive bays or drive trays. Or fans, come to that. What you do see, at first glance, looks like two braces running from front to back. These are the top fan mounts that support fans from 92mm up to 140mm, or a 240mm water-cooling radiator.

Then you notice eight (four per side of the case) straight metal brackets, which is where the clever bit comes in. These are 'Universal Brackets' that can be used in any position along the side panels. Yes, they have no fixed position, so you could go for some funky-looking setups. The brackets are held in place by retention clips at the top, which can be quite fiddly to fit. Your cooling fans (up to 140mm) and drives (2.5-inch or 3.5-inch) are screwed to these brackets. Drives can be placed vertically or horizontally, and, just like the top fan mounts, the brackets also support liquid-cooling radiators.

DRIVES GALORE

The top of the case holds three long cooling vents, while on each side there is a pair of square vents. Each of these boasts a plastic mesh that is easy to remove to keep clean. A nice touch is that the metal frames holding the mesh in place are held by tiny magnets embedded in the case. These, along with the lid, are the only tool-free items in the case. For everything else, you'll need a screwdriver.

How many drives does this Streacom case support? Well, the maximum number is... wait for it... up to 24. Yes, 24 2.5-inch drives, or a dozen 3.5-inch drives, but only if you're using a mITX motherboard. With a standard ATX board, it shrinks down to a comparatively measly couple of 2.5-inch drives and four 3.5-inch drives.

After all that, it seems a bit boring to discover that the PSU and motherboard are fitted in the traditional way. The case supports ATX, mATX and mITX format motherboards, plus PSUs up to 320mm long. There's a 135mm height limit for the CPU cooler, while the maximum length limit for a graphics card is 310mm.

The build quality is superb. Made from 4mm 6063 aluminium throughout, the outer panels have been sand-blasted for a first-class finish. The case is also available in black and there's not a rivet in sight, the whole case having been put together with screws – it's been a while since we've seen that. And the manual is excellent, with clear, coloured drawings explaining everything. Even all of the different mounting screws have their own resealable plastic bag. **–SIMON CRISP**

VERDICT 8

Streacom F12C

+ STREAMING Superb build quality; innovative internal design; ease of access.

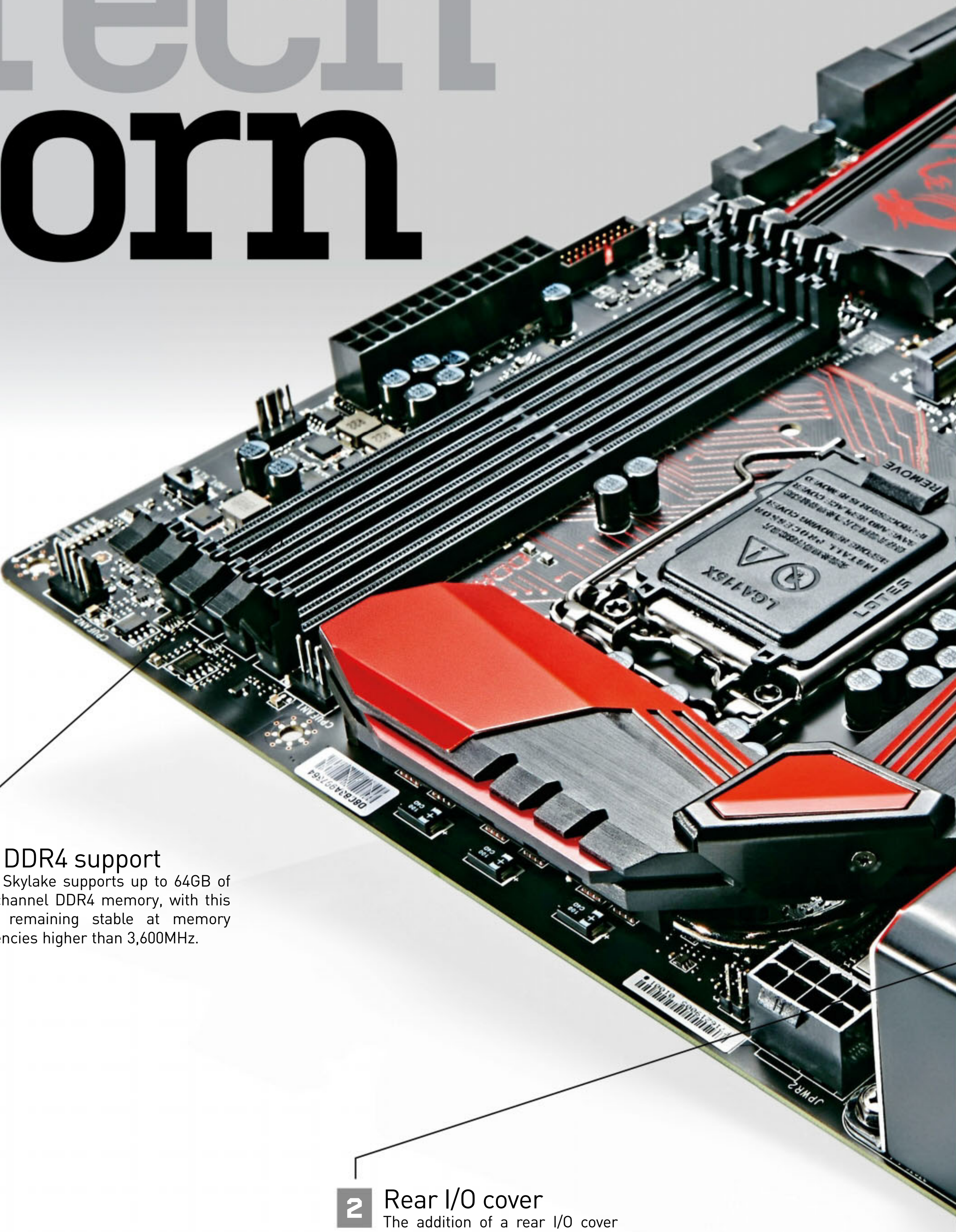
− BOTTLENECK Lack of front I/O ports; doesn't include any fans; pricey.

£179, www.streacom.com

SPECIFICATIONS

Form factor	ATX, mATX, mITX
Dimensions (W x H x D) & weight	440 x 320 x 184mm / 4.4kg
Cooling	None supplied
CPU cooler clearance	135mm
Graphics card max length	310mm
Storage support	2x 2.5-inch, 5x 3.5-inch (mITX up 24x 2.5-inch or 12x 3.5-inch)

Tech Porn

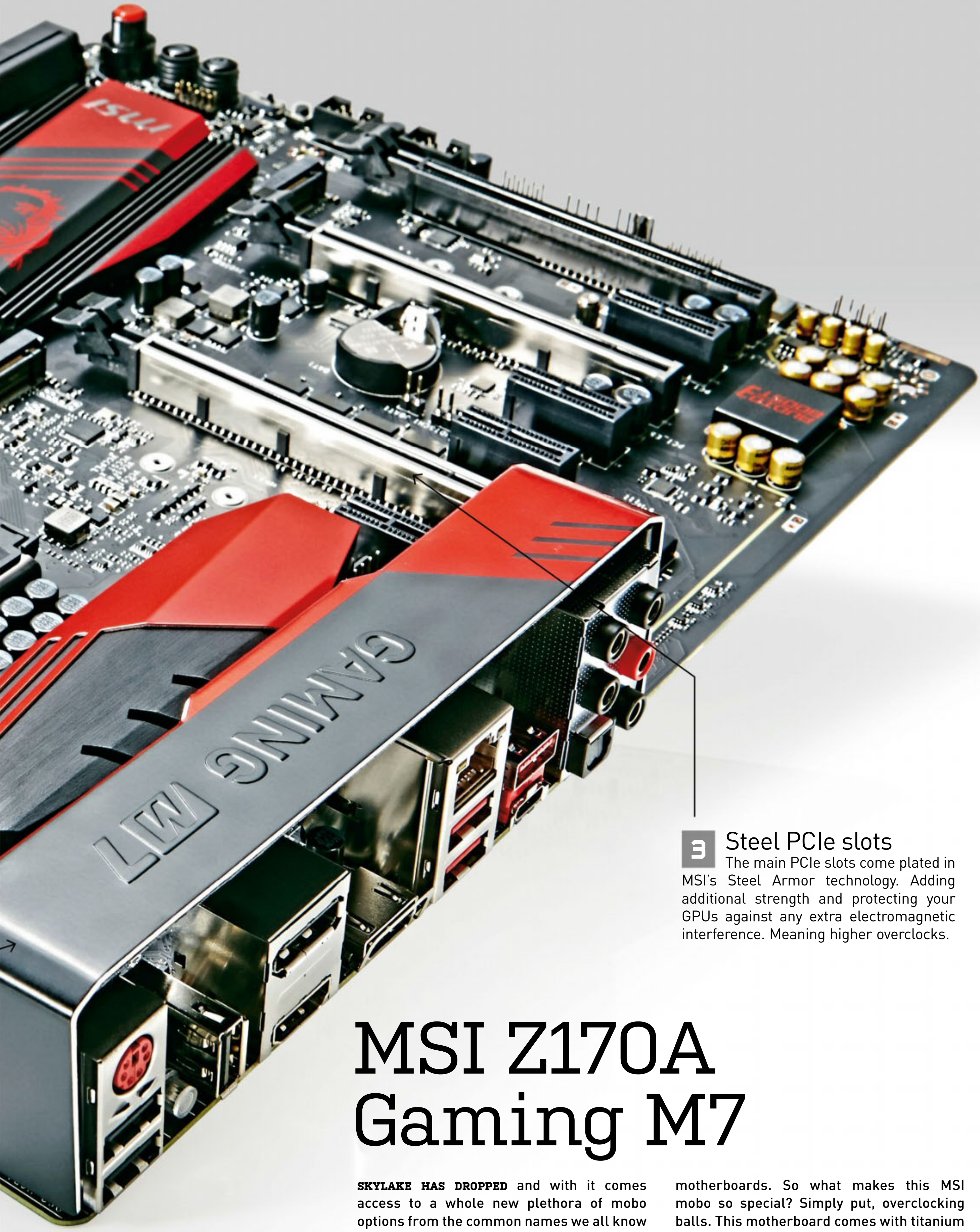


1 DDR4 support

Skylake supports up to 64GB of dual-channel DDR4 memory, with this board remaining stable at memory frequencies higher than 3,600MHz.

2 Rear I/O cover

The addition of a rear I/O cover hides all of the ugliness of those connectors and gives your motherboard and rig a cleaner all-round look. Build yourself a PC you can be proud of.



3 Steel PCIe slots

The main PCIe slots come plated in MSI's Steel Armor technology. Adding additional strength and protecting your GPUs against any extra electromagnetic interference. Meaning higher overclocks.

MSI Z170A Gaming M7

SKYLAKE HAS DROPPED and with it comes access to a whole new plethora of mobo options from the common names we all know and love. None so more than MSI, a company renowned for its military-grade components.

This MSI Z170A Gaming M7 is no exception, and it's one of many in MSI's renewed gaming lineup. Being the middle child in a product series is always difficult for any component part, and that's never more true than in motherboards. So what makes this MSI mobo so special? Simply put, overclocking balls. This motherboard comes with titanium chokes and highly efficient capacitors. It overclocks our barmy chip all the way up to 4.7GHz. But more than that, it's a stunning board. The PCB features a matte black finish, topped off with glorious metallic heatsinks and a rear I/O cover that's rarely seen at this price point. –ZAK STOREY

RIG BUILDER

BY DAVE JAMES

Build Your Perfect PC

Whether you're upgrading your PC or starting anew, this is the best kit

ONE OF THE JOYS OF OWNING A PC is that you can upgrade it as you go. Need higher frame rates in games? Drop in a newer graphics card. Want more power elsewhere? Grab a new processor or go for that old favourite: the memory boost. There's a wealth of upgrades that can transform your machine, plus you can change slowly over time to suit your budget, so you rarely have to suffer a sluggish rig for long. Every now and then, the best possible upgrade is to dump your current rig and start afresh by building a whole new machine from scratch.

What sort of machine should you build, though? Which items are important? Which work well together? How much should you be budgeting for? That's a lot of questions, and getting the right answers means having to go and research all the current trends in order to make the best decision. Before you do that, though, take a look at our guide. You'll discover that we've taken the hard work out of the equation and presented you with three machines that fit three different budgets. Our budget PC will get you gaming at 1080p for a bargain price, our mainstream machine will cope with pretty much anything at 1440p, and our high-end rig will do pretty much whatever it wants…

On these pages are our recommendations for putting together those budget, mainstream and silly high-end machines. These rigs all include a screen and peripherals in the ticket price, so if you're keeping your existing goodies then you'll have more cash to spend elsewhere. And what's our recommendation if you find yourself with that pleasant problem? Either get a larger SSD or a more powerful GPU. Happy building you lovely people!

HOW TO… BUY A GPU

THE GRAPHICS CARD IS ONE OF THE biggest upgrade purchases you can make for your performance PC. It's also one of the easiest – open up the case, slot it in and power it up. Simple as juicing citrus.

So, making the right choice is vital, especially as there are so many different options around at the moment. Essentially, it's almost entirely down to your budget. Buying the most powerful single-GPU card you can afford is always a good rule of thumb, but it's always worth ensuring that your power supply is capable of feeding it enough juice and has the right connectors.

So long as your PSU has a pair of 8-pin PCIe power connectors, you should be golded, but always check that your PSU's capacity matches the recommended spec for your prospective GPU. Finally, a word on multi-GPU purchases. Beware. You can get better average frame rates, but an equivalently priced single card is always going to be a better experience.

BUDGET

MOTHERBOARD	
MSI B85M-E45	£48
CPU	
Intel Pentium G3258	£52
MEMORY	
Crucial 2x 2GB DDR3 1,600MHz	£20
GRAPHICS CARD	
MSI GTX 750 Ti OC	£100
SOLID-STATE DRIVE	
OCZ ARC 100 240GB	£69
CPU COOLER	
Intel Stock Cooler	N/A
POWER SUPPLY	
Silverstone Strider E 500W	£45
CHASSIS	
Corsair Carbide 200R	£49
OPTICAL DRIVE	
LiteOn IHAS124-14 24x DVD±RW	£10
SCREEN	
AOC E2250SWDNK	£73
TOTAL	**£466**

MAINSTREAM

MOTHERBOARD	
Asus Z97-A	£114
CPU	
Intel Core i5-4690K	£165
MEMORY	
Corsair Vengeance LP 8GB	£41
GRAPHICS CARD	
XFX Radeon R9 290	£232
SOLID-STATE DRIVE	
Crucial MX100 512GB	£152
CPU COOLER	
Enermax ETS-T40	£38
POWER SUPPLY	
OCZ ModXStream Pro 500W	£59
CHASSIS	
Cooler Master CM690	£52
KEYBOARD	
Corsair Vengeance K65	£65
SCREEN	
Viewsonic VX2363Smhl	£125
TOTAL	**£1,043**

HIGH-END

MOTHERBOARD	
Asus X99 Deluxe	£288
CPU	
Intel Core i7-5960X	£779
MEMORY	
Corsair Vengeance LPX 16GB	£122
GRAPHICS CARD	
Nvidia GeForce GTX Titan X	£768
SOLID-STATE DRIVE	
Intel SSD 750 Series 1.2TB	£813
CPU COOLER	
Cooler Master Nepton 240M	£77
POWER SUPPLY	
CM Silent Pro Gold 800W	£135
CHASSIS	
CM Cosmos 2 Ultra	£264
KEYBOARD	
Corsair Vengeance K70	£112
SCREEN	
Philips BDM4065UC	£600
TOTAL	**£3,958**

BUDGET

When every pound counts, spend them wisely

MOTHERBOARD

MSI B85M-45

With the change in Gigabyte's previously impressive B85M-D2V we've switched to the slightly better MSI board for our budget build.

CPU COOLER

Intel Stock Cooler

The Pentium Anniversary chip is a very cool-running CPU, even when overclocked. We managed a stable 4.2GHz on this stock Intel cooler.

MEMORY

Crucial 4GB 1600 DDR3

Memory pricing continues to be incredibly volatile, but it's still a great time to squeeze more sticks into your rig. You really should see 4GB as the minimum.

CPU

Intel Pentium G3258

Poor AMD, it's a clean sweep for Intel on all our recommended rigs. The new Pentium is simply the best budget chip around right now, offering Haswell for peanuts.

GRAPHICS CARD

MSI GTX 750 Ti OC

Nvidia's latest GPU is quite a feat of engineering because of that brand new Maxwell architecture. The MSI card is a bargain.

SOLID-STATE DRIVE

OCZ ARC 100 240GB

OCZ's ARC 100 drive may not be the quickest, but it's great value, incredibly consistent and quicker than Crucial's MX100 at this capacity.

POWER SUPPLY

SilverStone Strider E

We may be talking about a budget rig here, but it's still a hefty chunk of cash to risk on a no-name power supply. This 500W Silverstone PSU will give you peace of mind and all the PCIe leads you need.

OPTICAL DRIVE

LiteOn IHAS124 DVD+RW

We really wonder whether you actually need an optical drive anymore, but for now we'll err on the side of caution and include one in the list. Don't feel bad if you forget to buy it though.

CHASSIS

Corsair Carbide 200R

Much more impressive than its price tag may lead you to believe, the clean lines and added extras of this chassis make it the budget case to beat. An understated bargain.

SCREEN

AOC E2250SWDNK

This 21.5-inch panel has a native resolution of 1920 x 1080 and looks pretty good despite that ridiculously low price tag. It's no IPS-beater, but it'll do for half the cash.

MAINSTREAM

A stunning rig doesn't have to cost a fortune

MOTHERBOARD
Asus Z97-A

We've seen a lot of Z97 motherboards since this Asus offering landed, but nothing newer has managed to push it off this list. Great features at a great price. Simple really.

CPU COOLER
Enermax ETS-T40

Enermax has simply amazed us with this, its first CPU cooler. The performance is excellent, the price is astonishing, it's easy to fit and it isn't so big that it limits your case or mobo choices.

MEMORY
Corsair Vengeance LP 8GB

This pair of 4GB sticks will give you all the performance you could ever want, and they're in stormtrooper white. They'll only take up two slots in the board for upgrading, too.

VENGEANCE
VENGEANCE

COOLER MASTER

GRAPHICS CARD
XFX Radeon R9 290

In order to shift units out of the channel, AMD's top cards of the last generation are dropping in price. The R9 290 is great value, if you can't stretch to the 290X.

CPU
Intel Core i5-4690K

For almost the same price as the ol' 4670K, you can pick up one of the newer Devil's Canyon CPUs. It's only got a 100MHz clock boost, but the new TIM helps with overclocking.

SOLID-STATE DRIVE
Crucial MX100 512GB

Crucial has made a big splash in the SSD market with this chunky drive. The 512GB version is quicker, larger and cheaper that the pricier M550.

POWER SUPPLY
OCZ ModXStream Pro

If you want to build a performance machine, you're going to need a powerful PSU. This 500W baby will power the rig, with extra to spare. It's quiet as well.

KEYBOARD
Corsair Vengeance K65

We love a good mechanical switch keyboard here on *PC Format*, and Corsair is making some of the best. The K65 is a great compact option, with a compact price to boot.

CHASSIS
Cooler Master CM690

The CM690 eschews silly gimmicks in favour of producing a no-nonsense chassis that has plenty of cooling options for your mainstream rig. There's space aplenty inside, and all at a reasonable price.

SCREEN
Viewsonic VX2363Smhl

The old 23-inch Viewsonic IPS seems to be EoL now, but this white one has got the budget IPS panel and decent performance for its bargain price tag.

HIGH-END

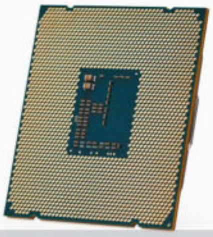
For when you *really* want to treat yourself

MOTHERBOARD
Asus X99 Deluxe

As usual this Deluxe board from Asus is absolutely stuffed with funky features. It's one of the finest, and best-looking, X99 boards around and not a bad overclocker either.

CPU
Intel Core i7-5960X

If you're after the fastest, most advanced CPU around, then this 8-core, 16-thread Haswell-E is it. There's also the 6-core i7-5820K for a more reasonable £300, but the 5960X is the pinnacle of modern CPUs.



CPU COOLER
Cooler Master Nepton 240M

Why settle for a reasonable overclock when you can hit 5GHz? This kit is speedy, boasts incredible performance and is quiet in operation. Everything you'd want, in other words.

MEMORY
Corsair Vengeance 16GB

The Haswell-E platform is the first to bring DDR4 to the consumer. That does come at a hefty price, but it's damned quick.

GRAPHICS CARD
Nvidia GTX Titan X

The dual-GPU R9 295X2 is still the quickest overall card, but the GM 200 in the Titan X makes it the best all-rounder. It's almost as quick and will never suffer the ignominy of multi-GPU issues in-game.

SOLID-STATE DRIVE
Intel SSD 750 1.2TB

Intel's latest drive is the very first consumer-focused SSD to utilise the new NVMe protocol. And that makes it super-quick, like an Extreme Edition SSD. With a price to match.

POWER SUPPLY
CM Silent Pro Gold 800W

Cooler Master continues to impress with its power supply units, and this wonderful box of tricks managed to scoop the gold award in our exacting test way back in PCF246.

KEYBOARD
Corsair Vengeance K70

Corsair's update to the older Vengeance keyboard rights all its older sibling's wrongs. It's also a truly stylish gaming board with the red backlight glowing against its black-brushed metal chassis.

CHASSIS
CM Cosmos 2 Ultra

Cooler Master has always been an impressive maker of cases, but it has truly stunned us with this chassis. Yes, it's expensive, but if you can afford to drop this much on your case, you'll be more than happy.

SCREEN
Philips BDM4065UC

This 40-inch 4K behemoth is the first screen to make us think that super-high resolution actually looks super. It's a decent VA panel and a great price, too, and will really take advantage of the R9 295X2.

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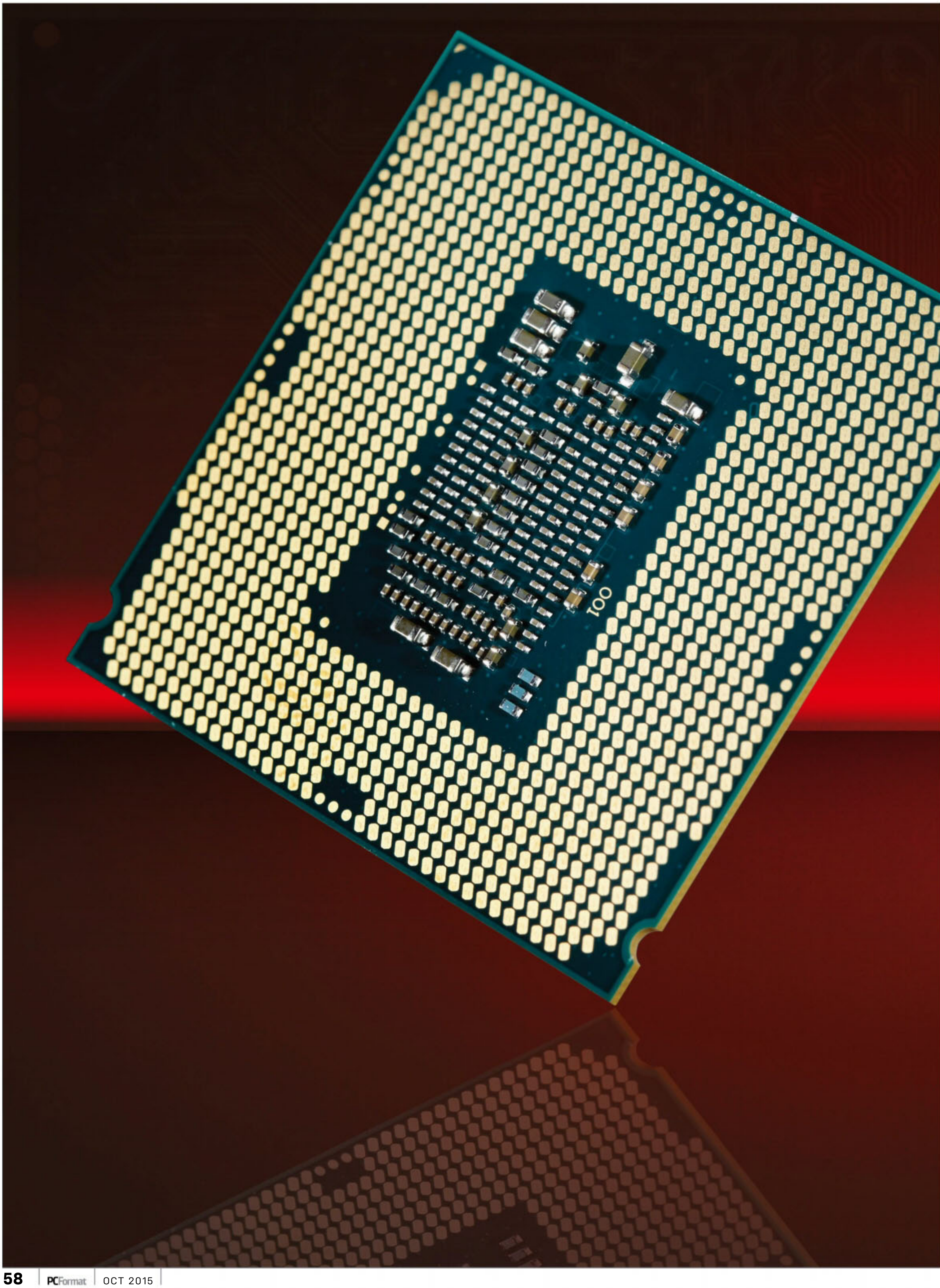
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Skylake Deep Dive

Intel's latest architecture is finally here, so we got investigating

BY ZAK STOREY

Well, here you have it folks. Skylake hath cometh to the people, and with it comes the absolute pinnacle of Intel's micro-processing technology. Let's just forget about Broadwell. Its short life time has been invaluable to us PC enthusiasts, but alas, it was never meant to be.

Taking us from that blasted 22nm architecture down to 14nm was an incredible feat. But it was too little, too late. Ultimately, the little chip paid the price, doomed to retire to an early death. A victim of its own architecture's difficult production methods.

Broadwell's glorious sacrifice, however, has given us one phenomenal gem – Skylake. If the X99 chipset and Haswell-E was the premium-grade reboot that PC enthusiasts needed, it's safe to say that Z170 and Skylake is about to do the same for the rest of us lowly four-core lovers. And let's face it, we've sorely needed it.

The last three generations of Intel CPUs have hardly seen a vast improvement over the original Sandy Bridge chips, and it's about time we were given CPUs that mopped the floor with that dusty old dog. Yes, Intel's cores may generally run rings around the competition when it comes to compute performance, but a 5 per cent performance increase and 10 per cent power reduction, year after year, just isn't exciting enough to warrant tattooing the Intel logo on the inside of our thighs. Not just yet.

Regardless of how it likes to name its early morning glow chipsets, Intel needs to knock this one out of the park. And although it's pretty much cemented itself in the world of enthusiast-grade CPUs, another 5 per cent performance boost just isn't that interesting, especially when most games currently struggle to utilise anything more than four cores anyway. Hell, we'd still recommend the i5-2500K if it was still available for sale.

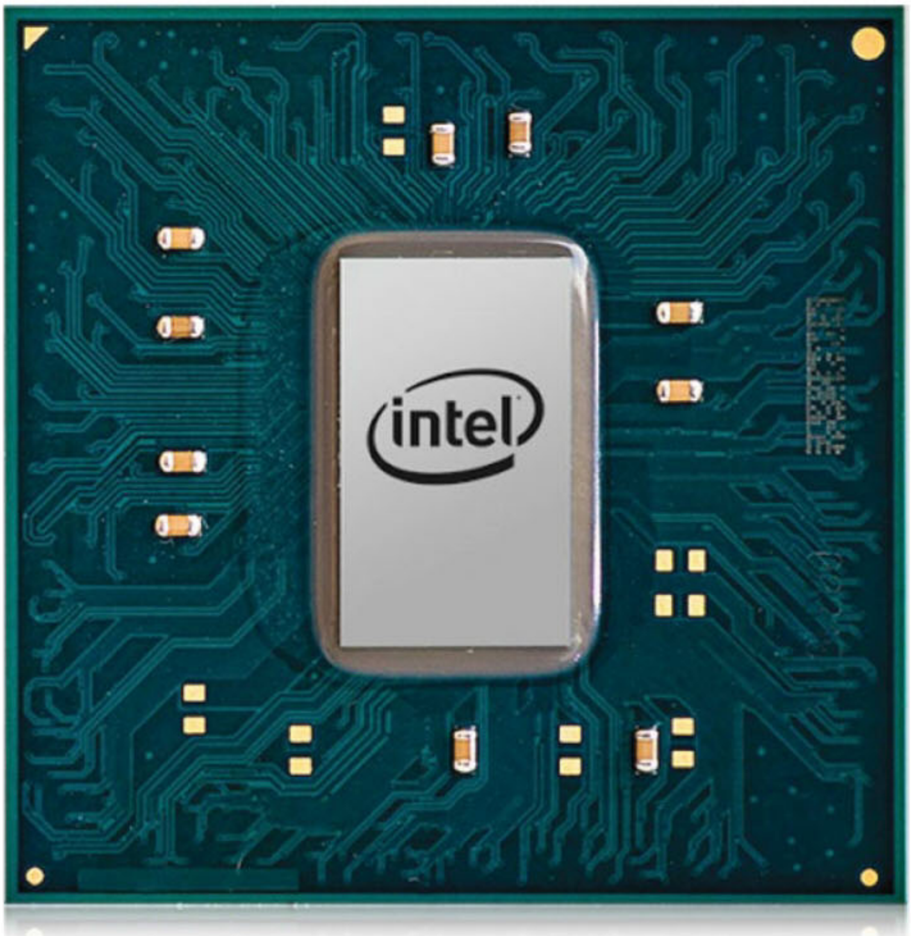
So what was it that kept Intel behind for so long? What do these chips represent to us? And what shiny new features will it bring to the table? Read on to find out what we discover in our in-depth report.

Skylake and the Z170 Chipset

Let's start with the basics. At this point, we have the Intel Core i5-6600K and the Core i7-6700K – the premium overclocking CPUs for the enthusiast users. These are the flagship models of Intel's consumer brand. Processors that, by their very nature, are designed to be pushed to the limits in the hunt for number-crunching, benchmark-rendering, overclocking perfection.

But what does Skylake bring to the table that Haswell didn't? Well, a 14nm processor for starters. Similar to the now-redundant Broadwell, yet a lot more promising. Intel has dropped the FIVR (Fully Integrated Voltage Regulator) from the CPU die and left voltage control entirely down to the motherboard manufacturers. This allows aftermarket partners to control how they supply power to each individual voltage controller located onboard the chip. What's exciting about this is how much variance we may start to see in the motherboard market once again. It's an area where, for a long time, it's been very difficult to differentiate between or even justify the cost of a £300 board over a £100 one. It might make choosing your motherboard about more than just buying the prettiest one for your budget. And that's fantastic, especially for competition's sake.

On top of all this loveliness, the Z170 chipset has a vastly expanded array of storage options – including Intel's new U.2 PCI Express connector, an additional 12 PCIe lanes to allow greater performance when running NVMe, and PCIe M.2 drives (an upgrade from gen2 to gen3). There's also continued support for six SATA 6Gb/s devices, up to 10 USB 3.0 ports and 14 USB 2.0 ports. Rather surprisingly, however, there isn't any native support for USB 3.1 (both Type A and Type C). Intel has stated that it's banking on Thunderbolt 3 being the more appealing solution to this particular platform. Although this seems a little short-sighted going forwards, only time will tell whether that will hold true or not. Who knows, maybe 3D Xpoint memory sticks will be powered by Thunderbolt and Intel will become our silicon overlord.



Hello Z170, aren't you a pretty little thing?

MEMORY MUSCLE

But the biggest and most exciting feature by far is the support for DDR4 RAM, the final advancement beyond the limited 2,400MHz DDR3 band. Z170 motherboards will support up to 64GB of memory, from 2,400MHz all the way up to 4,000MHz and beyond, advancing the ageing platform far past that of its Broadwell and Haswell cousins.

But don't fret if DDR4 prices are still a little too steep, and you have a few DDR3L RAM sticks kicking about, Skylake is backwards compatible. Albeit only with the low-voltage economy version, as opposed to the last platform's DDR3 offerings. That means that if you'd rather just use a DDR3L-enabled motherboard, you can do just that. But saying that, these boards do seem to be few and far between. The only manufacturer we know of that has boards with this feature for the foreseeable future is Biostar, a company that didn't exactly score very highly in its last review here at *PC Format* (September issue).

If you're dipping into the funds to build a new rig, you really should be looking at DDR4. Prices have dropped by roughly half since they were launched in October last year, which means you're only paying around £20 extra for the same capacity of RAM at a far higher frequency than you once were.

SPECIFICATIONS

	Intel Core i7-6700K	Intel Core i7-4790K
Lithography	**14nm**	**22nm**
Frequency	4GHz (Turbo to 4.2GHz)	4GHz (Turbo to 4.4GHz)
Cores/threads	4/8	4/8
Cache	8MB	8MB
TDP	91W	88W
DDR support	DDR4/DDR3L – 64GB Max	DDR3/DDR3L – 32GB Max
PCIe configuration	1x 16, 2x 8, 1x 8, 2x 4 – Gen3	1x 16, 2x 8, 1x 8, 2x 4 – Gen3
Intel graphics	Intel HD Graphics 530	Intel HD Graphics 4600

Still not interested? Do you consider yourself a bit of a speed freak, but memory just doesn't float your boat? Well, ladies and gents, we have one last nugget of juicy information for you – that's the inclusion of PCIe Raid 0, 1 and 5 support, allowing end users to RAID multiple NVMe drives together.

This has the potential to increase transfer read and write speeds all the way up to 3,500MB/s and beyond, approximately six times faster than your traditional SSD.

SPECIFICATIONS

	Z170 Chipset	Z97 Chipset
PCIe lanes	20 lanes Gen3.0	8 Lanes Gen2.0
SATA connectivity	6x SATA Ports / eSATA	6x SATA Ports / eSATA
USB support	10x USB 3.0 / 14x USB 2.0	6x USB 3.0 / 8 USB 2.0
Ethernet	10/100/1000 MAC	10/100/1000 MAC

A New Architecture

Skylake's new architecture has been painstakingly woven from Intel's manufacturing plants and engineering genius. Having to drop Broadwell, even just to make its production deadlines, Skylake is the first widely available 14nm CPU microarchitecture.

It's a chip that's situated in the brand-spanking new 1151 socket (yes, one whole extra pin), alongside the Z170 chipset. Although not the consumer's first access to a 14nm chip, it'll be the most commonly sought-after processor line going forward, the go-to buy for us PC enthusiasts, overclockers and system builders looking for the best mid-range processors for our towers of power.

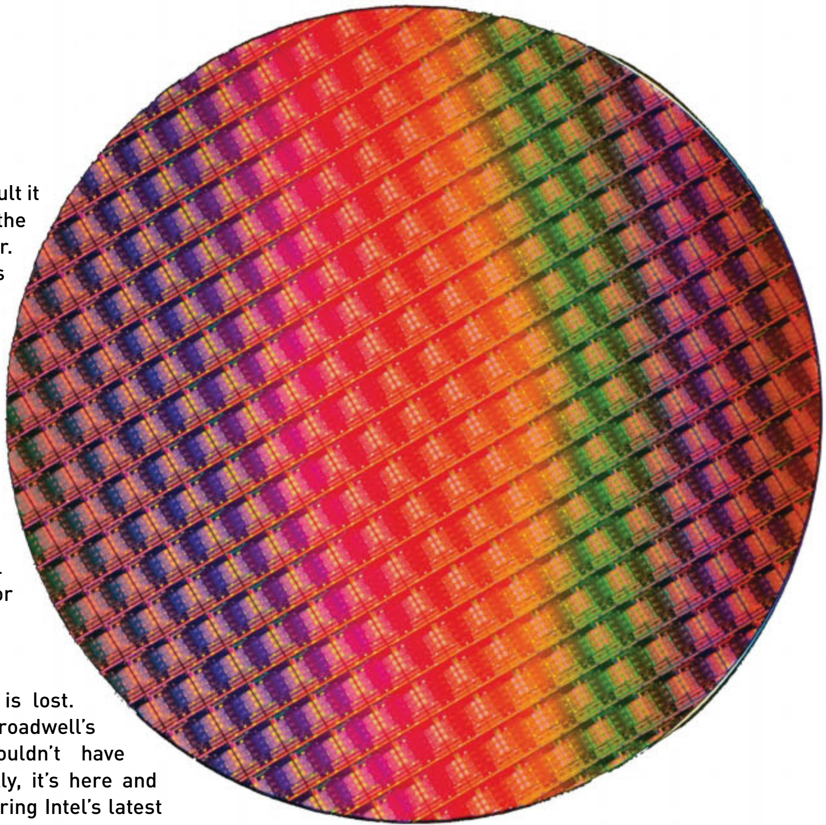
To build a processor like Skylake, you have to start from the ground up, and that's with the silicon. Essentially, a wafer-thin slice of computing crystalline goodness, silicon provides the basis for what the CPU will become, before it's cut out and embedded into the CPU superstructure that we're all so familiar with. Utilising a 193nm ArF lithography (basically a high-powered laser), Intel has to etch in all of the details for each and every processor, from each transistor upwards, essentially crafting every detail that makes a CPU a CPU.

The difficulty lies in the lithography itself. The laser in its most minute form is 193nm wide. To put that into perspective, the width of a human hair is 75,000nm across. So, to get that tiny beam of light small enough to even create one single transistor, it's necessary to utilise a variety of different technologies and optics to split the beam into even more ridiculous molecular sizes without necessarily losing any of the additional power that comes from the original beam. The smaller you go, the more difficult it becomes to split the laser down further. Ultimately, this is why it's taken Intel so long to go from the 22nm die size to 14nm, and thus why Broadwell has had such a brief (and rather unexciting) shelf life. We can only hope that this will not be the case for the 10nm chips.

KIT CRAZY

But alas, not all is lost. If it wasn't for Broadwell's sacrifice, we wouldn't have Skylake. Thankfully, it's here and on schedule, ensuring Intel's latest flagship dodged a similar fate. For release dates we can only speculate at this point, but rumour has it the full desktop lineup should be available by the end of this year, with mobile laptop processors making it to market by early 2016. Again, speculation and rumour on our part.

DDR4 memory is a crucial part of Intel's marketing strategy here. Although it's the next natural progression, the launch price was more than enough to put most people off their dinner. Fortunately, kits have been around since October 2014 and have slowly dropped in price since then with the launch of the extreme edition processors. With Skylake's release (and dual-channel support) comes a wide variety of dual-channel kits at almost a comparable price point to DDR3. If you're still unsure what memory to choose, however, don't worry. Intel has you covered. Memory kits from the likes of Crucial, Corsair, G. Skill, Patriot, Kingston and Adata have all been approved by Intel, just to keep you safe of mind.



This wafer is probably worth quite a bit.

The most exciting feature is the support for DDR4, the first advancement beyond 2,400MHz DDR3.

The Z170 motherboards, on the other hand, have been making the rounds for quite some time now, debuting with a wide variety of manufacturers showing off their long-awaited products at Computex, back in June. And man, do they look good! Most mainstream board partners have had these things ready since last Christmas (or thereabouts), so if you must have the latest hardware, or are thinking it's time for an upgrade, you'll be more than spoilt for choice.

DirectX 12 could well be a game changer, literally.

Power and Performance

So, how does Skylake actually perform? Well, it isn't the absolute be-all-and-end-all of chip advancements. If you're only one generation behind, with Devil's Canyon, you'll only see around a 10–15 per cent improvement in benchmarks and rendering times, clock for clock.

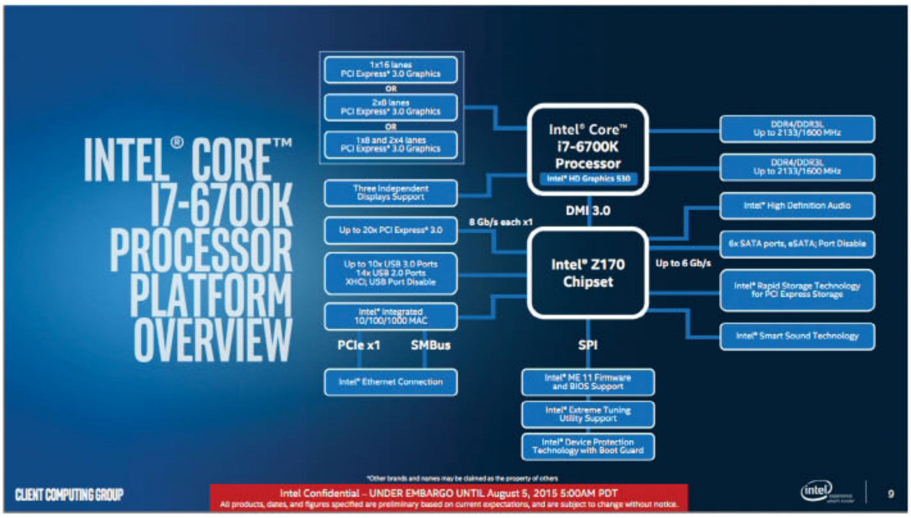
In Cinebench, we saw an outright 11 per cent increase in performance over Intel's Core i7-4790K. Not too shabby to say the least, but not exactly beyond the realms of what we expected.

What is interesting is how far we can push the powerful four core. Skylake's overclocking potential is well documented as being far greater than that of its last three predecessors. And once we cranked our chip all the way up to 4.8GHz (a conservative clock, admittedly), we actually managed to push this core to perform just a little under that of an i7-5820K extreme edition processor at stock. Interested? You should be. It's certainly not impossible to get this processor even higher than that. Reports have come in of people clocking 5.2GHz on air alone, all dependent on the motherboard more so than ever. In fact, we managed to achieve these benchmarks on an entry-level £100 Asus motherboard.

All in all, this chip provides us with a very unique insight into what the 14nm processor series can do. But let's cut to the chase. Why is 11 per cent good? Is it really worth it? Well, consider it this way. If it's 10 per cent better than an i7-4790K, it'll be roughly 20 per cent better than a 4770K, and 30 per cent better than a 3770K, and so on.

If you're still stuck on the ever-faithful Sandy Bridge architecture [like some of our writers here are... *cough*], then this might be the perfect time for you to upgrade that CPU and take advantage of all of those additional chipset features and processing power.

With features galore, it could be time for an upgrade.



INTEL® CORE™ I7-6700K PROCESSOR PLATFORM OVERVIEW

1x16 lanes PCI Express* 3.0 Graphics
OR
2x8 lanes PCI Express* 3.0 Graphics
OR
1x8 and 2x4 lanes PCI Express* 3.0 Graphics

Three Independent Displays Support

Up to 20x PCI Express* 3.0

Up to 10x USB 3.0 Ports
14x USB 2.0 Ports
XHCI; USB Port Disable

Intel® Integrated 10/100/1000 MAC

PCIe x1

SMBus

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Intel® Core™ i7-6700K Processor

Intel® HD Graphics 530

DMI 3.0

8 Gb/s each x1

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Up to 6 Gb/s

SPI

Intel® ME 11 Firmware and BIOS Support

Intel® Extreme Tuning Utility Support

Intel® Device Protection Technology with Boot Guard

DDR4/DDR3L Up to 2133/1600 MHz

DDR4/DDR3L Up to 2133/1600 MHz

Intel® High Definition Audio

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9

EFFICIENCY DRIVE

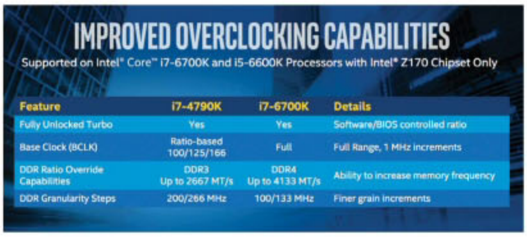
When it comes to literal power consumption, Skylake stands head and shoulders above the rest. We decided to build a basic test system to give the new girl a run for her money. It consisted of an Nvidia GeForce GTX 980, four sticks of Kingston HyperX memory, one 240GB Samsung Evo and a more traditional 2TB Seagate something or other. Under load (Prime 95 & Furmark), the rig pulled a total of 340W from the wall, utilising only half of the 750W power supply we had it running on. If nothing else, these chips will be fantastic for small form-factor builds and Steam Machines. Hell, if you really wanted to, you could run SLI on a 750W power supply with little-to-no worries at all.

The biggest area of improvement for Intel has been in the integrated graphics department. That may not mean much for those of you buying into the K-line processors, as you'll probably also be investing in a dedicated GPU. However, utilising DirectX 12 to leverage the CPU effectively could improve frame rates considerably in games. That may not be so beneficial for Twitch and streaming enthusiasts, but it harks back to what AMD was trying to implement with its Mantle API, allowing Intel to carefully leverage the processing power for what computational tasks each core is better suited to handling.

Overclocking Potential

Inherently, this generation of chips is vastly different to Haswell and the Devil's Canyon remit that we received last year. Primarily, this is down to Intel's decision to remove the FIVR from the chip design.

The FIVR, or Fully Integrated Voltage Regulator, was a component piece of the CPU found in any previous generation of Intel processor. Its sole purpose was to regulate and control the overall voltage that went directly into each part of the compute portion of the CPU, such as the DRAM controller, and the VCore. By removing this, Intel has handed voltage control to the motherboard manufacturers. This means that, instead of a standardised level of voltage operating across the entire platform, it's now possible for board partners to implement specific voltages for each of those compute portions we mentioned earlier.



IMPROVED OVERCLOCKING CAPABILITIES

Supported on Intel® Core™ i7-6700K and i5-6600K Processors with Intel® Z170 Chipset Only

Feature	i7-4790K	i7-6700K	Details
Fully Unlocked Turbo	Yes	Yes	Software/BIOS controlled ratio
Base Clock (BCLK)	Ratio-based 100/125/166	Full	Full Range, 1 MHz increments
DDR Ratio Override Capabilities	DDR3 Up to 2667 MT/s	DDR4 Up to 4133 MT/s	Ability to increase memory frequency
DDR Granularity Steps	200/266 MHz	100/133 MHz	Finer grain increments

The Core i7 still rules the roost when it comes to overclocking potential.

But are they cooler than Devil's Canyon? Skylake is quite cold, no doubt partly due to the removal of the FIVR we mentioned earlier. This enables you to ramp up the core clock frequency considerably, without worrying about thermally throttling the chip. But you're still going to need an aftermarket cooler for the majority of your overclocking attempts, as it will provide a great deal more headroom when trying to achieve those higher clockspeeds.

BASE CLOCK BATTLES

In our testing, we found the Core i7-6700K to be a solid 3–4°C cooler than the Devil's Canyon refresh under load. And although Intel has promised to reimplement the FIVR, this doesn't seem likely to happen until the iteration after Kaby Lake, known as Ice Lake. All in all though, we're not too sure whether losing the FIVR is a bad thing or not.

Another change that's come with Skylake is the ability to alter the base clock frequency in 1MHz increments. The base clock frequencies are currently 100/125/166MHz on Devil's Canyon. However, Skylake scraps the ratio-based system entirely, allowing higher overall overclocks for those willing to eke out every millimetre of power from their otherwise beastly new CPU.

It's important to note, however, that you'll need to adjust the core ratio to coincide with what target clockspeed you're attempting to achieve. For example, if you change the base clock to 300MHz and leave the core ratio at default, you'll end up trying to achieve a 12GHz overclock. Which, we think, is theoretically impossible at this point in time.

Conclusion

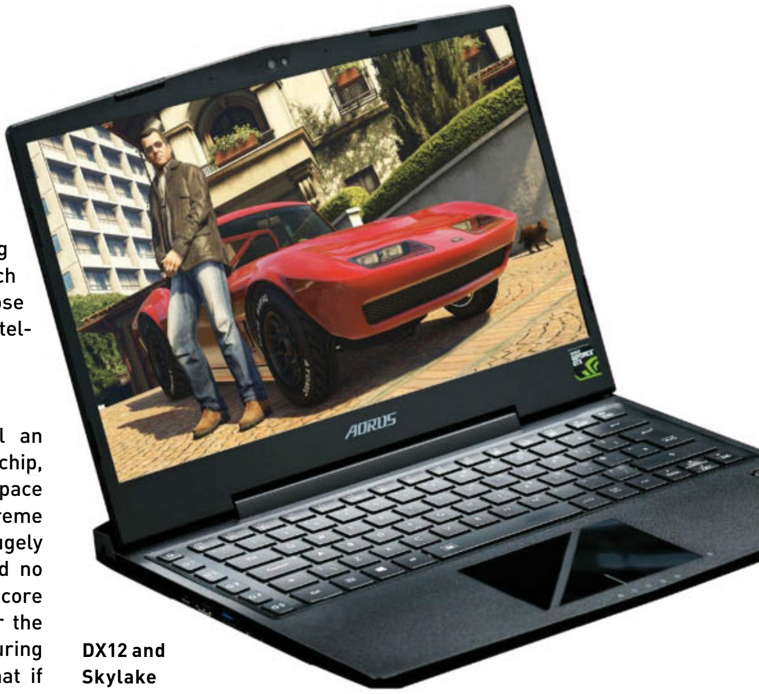
So, what does Skylake mean to PC enthusiasts like us? Well, probably that it's finally time for an upgrade, for starters. Intel is still top dog when it comes to single and multi-threaded processor performance, and this looks unlikely to change any time soon.

Hopefully, AMD will bring back some competition via the Zen cores, but who knows how far off that will be. What these K-series processors have shown us, however, is that Intel's famously weak integrated graphical horsepower has been increased considerably compared to the last series. And, although those running the overclockable chips are hardly likely to be utilising integrated graphics alone, this does give us a good insight into the capability of the more mainstream chips being released later this year, which is especially interesting for those running laptops and other Intel-powered mobile devices.

PROMISING FUTURE

As much as Skylake is still an incredibly competitive chip, however, it still doesn't hold pace with Haswell-E. The extreme edition processors benefit hugely from the additional cores, and no amount of Hyperthreading or core performance will beat that for the time being. What we did find during our testing of Skylake was that if you overclocked the CPU up to 5GHz, it actually matched benchmark performance with that of the entry-level model i7-5820K at stock. For an enthusiast-grade chip, that's one hell of an achievement.

Over the next few years, we'll no doubt see some incredible advancements when it comes to computational power. If Intel keeps this progress up, 10nm processors might not be as far away as many may think. And with 3D Xpoint landing sometime next year, the next phase may change how we look at the world entirely. It's an exciting time to be a tech enthusiast, that's for sure. ■



DX12 and Skylake gaming-capable laptops anyone?

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GAMING

BECAUSE GAMING IS A WAY OF LIFE

What Are You Playing At?

On stranger tides

> "A title's worth shouldn't be judged just on the size of its game world."

I'M A MESS. The game's credits are rolling and I'm a teary mess. I was a mess a few hours ago during its emotionally charged opening sequence, and now, with the series set up for what should be an incredible finale, I'm well… a bit of a mess.

And the cause of all this unmanly face precipitation? *Life is Strange*. More specifically, the contents of its fourth and penultimate episode. The indie-esque offering from *Remember Me* dev Dontnod has dug its interactive claws into my feeling gland and squeezed all the emotive juice out like a particularly ripe plum. The thing is, there isn't much game here when you break it down. Apart from the time-travel power that leading lady Max has at her disposal, most of your time is spent taking photography classes and chatting in poky little diners.

I've not even spent that much time with *Life is Strange* – roughly two-to-three hours per each of its four available episodes – when you compare it to the depressingly vast selection of RPGs I've lost most of my adult life to. I spent 200 hours in *Skyrim* before I finally stepped away from my Dovakin destiny. And yet, I never experienced an emotional experience as resonant as my short time in Arcadia Bay.

All comes down to story, a vital element that's often being lost when the scope of a game outweighs the flexibility of its plot. Modern trends in the triple-A space err towards bigger, open worlds that pulsate with innocuous ephemera. Even the best stories suffer dilution when stretched across 40 hours. It's an inevitable end-state for a medium designed to appeal to multiple demographics with varying tastes and attention spans.

For all our hunger for graphical fidelity and expansive worlds that procedurally generate into oblivion, nothing beats a finely woven story. Thick of plot and rich of character. A game's worth shouldn't be judged just on the size of its game world, but on the validity of its fiction. *Life is Strange* doesn't offer me the chance to join a Thieves' Guild or hunt my umpteenth talking dragon – it takes the mundane tasks of life and infuses them with a melancholic authenticity that places as much consequence in a line of dialogue as other games do in 20 hours of endgame combat. –DOM RESEIGH-LINCOLN

GENERATION PROC PG. 66

HIGHLIGHTS…

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Rocket League

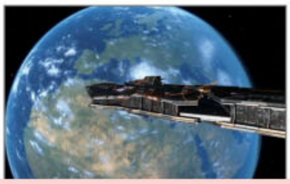
76
Ronin

RECOMMENDED…

THE WITCHER 3: WILD HUNT
CD Projekt RED
Once you're hooked on this giant, gorgeous open world, there's no turning back. **PCF307 p72**

GRAND THEFT AUTO V
Rockstar
A sublime Los Santos sandbox, fleshed-out characters and seriously bling graphics. It's the best *GTA* yet. **PCF305 p72**

PILLARS OF ETERNITY
Obsidian Entertainment
A perfect recreation of the *Baldur's Gate* era, it's an RPG that's huge in scope, full of complexity and rich in imagination. **PCF305 p74**



ELITE: DANGEROUS
Frontier Developments
Carve out your own unique experiences in a game that boasts everything that made the original such a classic. **PCF301 p70**

GENERATION PROC

How games have learned from art, music and maths – and how the world might learn from games

By Daniel Griliopoulos

And on the third day, God made the world. And He saw that it was rubbish. And He then looked at the other worlds that He'd made, and thought, "They're a bit bobbins, too, infallible as I am."

So He pondered for silent indefinites, as the void drifted tetchily on, waiting for time, space, gravity, bicycles and all the other concomitants of virtue and vice. Eventually, He got a bit frustrated. "Bollocks to it all," He thought, blasphemously. "Handcrafting a universe is for losers. I'll procedurally generate an infinity of them and just choose the best one." And lo, that was the morning of the third day, and He saw that it was good. So He went and watched fractal zooms on YouTube for the rest of the week.

As a child, I remember being fascinated by Mandelbrot. I didn't at that time know what the word meant, except that in the corner of our BBC-riddled IT room at school was a single, fast Acorn computer that the IT teacher treasured and guarded. The only thing he seemed to run on it was a Mandelbrot simulation, which we used to sit and watch over our lunch break. It would take ages to draw each screen as it zoomed in on part of the structure, which would always reveal more structure and more complexity. Eventually, sometimes, it would repeat.

A Mandelbrot drawing is a representation of a mathematical set – the set of complex numbers that do not tend to infinity; which is to say, equations involving imaginary numbers; which is to say, numbers that involve the square root of -1. Which is to say… that I didn't take maths past A-level and this is really difficult to understand. So I promise there won't be any more equations in this article. Really.

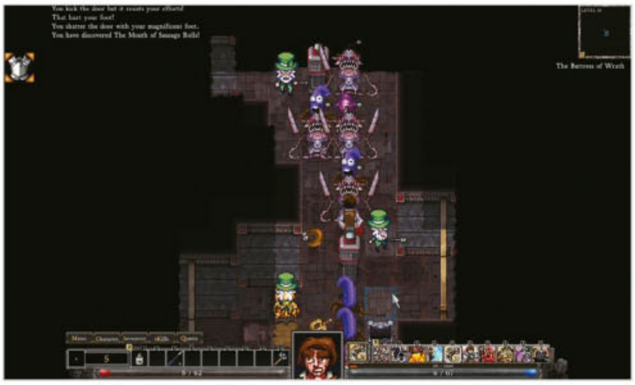
More interestingly for our purposes is that, whatever else Mandelbrot is, it's an equation that throws up astounding complexity and beauty without the user having to create anything themselves. Look closely and you can see it features spirals, valleys, seahorses, tentacles, antennae, double-hooks, islands. The mind's eye sees cityscapes, ships, people holding hands, trees and organic structures that have never existed. And all this is created from an equation?

Well, only with a computer. Fractal art, like Mandelbrot, mostly exists as an outgrowth of using iterative methods to solve polynomial equations, and that really requires a computer. Looking at generative pieces, it's hard not to agree that they're art – but the artist has at most set the parameters for their creation, not hand-crafted the piece, or in this case, hand-solved the maths.

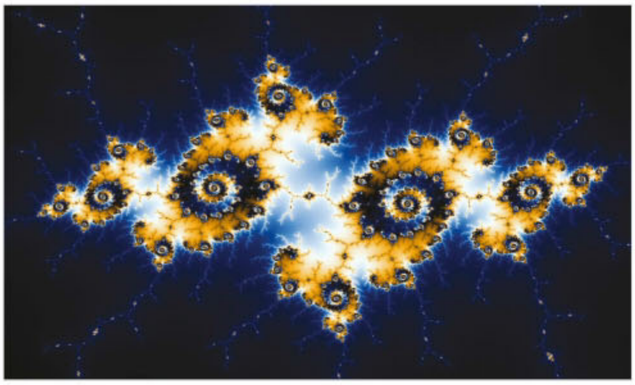
Similarly, 'generative music' can be constructed without direct user input. One could also argue that Bach's fugues were generative, given that they were based on a strict underlying mathematical process out of the control of the creator. There's even generative writing, which has grown from the 'cut-up' techniques of writers such as William Burroughs or Georges Perec, and France's mechanical-writing Oulipo school.

That's the heart of procedural generation. It's grown out of maths, through art and music, and it's taking over gaming. Where will it stop?

Few procedurally generated games have had the success of *Minecraft*, recently bought by Microsoft for $2.5 billion.



Roguelike indie game *Dungeons of Dredmor* has procedurally generated dungeons and items.



The Mandelbrot set produces infinite complexity from a simple formula, and many of its results look like abstract art.

“People have always been fascinated with creating unpredictable things by following rules,” explains Michael Cook, an academic who specialises in procedural game design. “Even children’s games where you pass along bits of folded paper and each write part of a story. It’s all about being delighted at something strange coming from nowhere in particular.

“We’ve dreamed of machines that make things for a very long time – Ada Lovelace wondered about machines that could write music long before Alan Turing was even born. I think there’s just something magical about the idea of something coming from nothing – and I still feel that magic each time I work on a new generator!”

A ROGUE'S HEART

Cook’s main project, Angelina, is a special case, which we’ll talk about later. But he’s right about our love of the emergent outgrowth of rule structures. “Of course, there’s nothing better at following rules than a computer, so it didn’t take long for programmers to give computers recipes for generating complex, beautiful things. Computers let us transform theoretical patterns and ideas like fractals and L-systems into amazing machines with moving parts that could be poked and examined and executed again and again.”

The most standard usage of procedural techniques in modern gaming is in roguelikes and indie games, such as *Minecraft*, *Dwarf Fortress* and *NetHack*. It’s an area that Nicholas Vining’s Gaslamp Games specialises in, and he’s adamant that it’s essential for certain genres.

“For the games we make,” says Vining, “you have to have procedural generation. Both *Clockwork Empires* (a steampunk colony builder with a Lovecraftian twist) and *Dungeons of Dredmor* rely on having a lot of replayability, and a good way to get replayability into a game is to have it change every time. You really want to have random geography and random levels and random stuff being thrown at you.”

> “It's being delighted by something strange coming from nowhere.”

No Man’s Sky will procedurally generate billions of worlds, ships and creatures.

But why use procedural generation? Surely we’ve got by perfectly well handcrafting them so far? “People want giant experiences, and value for money,” says Vining. “AAA games deal with this by giving them 100 hours of hand-massaged content – *Dragon Age: Inquisition* is the most recent example – but that doesn’t scale unless you’re making, you know, *Dragon Age*. (And then you’ll end up probably having to make money by DLC.) Being indies, we have to cheat. And frankly, hand-massaging 100 hours of content is more laborious than it needs to be.”

ON THE TUBE

Vining is also keen to make the game easy to share and non-repetitive – not merely for the end user, but to attract the YouTubers who mostly drive a game’s fame today.

“We’re now making games for players who want to also show themselves playing the game, on YouTube, and doing stuff. I think you’re stuck with that nowadays. I think *Minecraft* did it to us. So, you have to make a game where YouTuber X playing the game can have a completely different experience than YouTuber Y.

GENERATING ESCAPISM

Procedural game design academic Michael Cook said something very interesting. "Depending on how VR designers want to take the tech, procedural generation could be the defining technology of the VR age." As we've explored in previous months, AR and VR are taking the lessons from games and growing them into whole new fields – Oculus is even employing ex-Pixar staff to make VR kids movies.

Of course, like AAA games, VR has to be convincing to work, and the hardware can't do it alone. It needs tons of convincing content – a lot more than any game, because it has to be all around the player and in great detail. Procedural generation might not just be helpful in creating these worlds and objects, it seems essential.

Valve and HTC's Vive system adds even more complexity, given that it uses extra cameras to map the dimensions of the room. That means shifting the size and shape of the rooms you're experiencing through the device, which means the designers will have to create the game with variable locations for cues and objects. Your fantasy tavern might just be a few feet across and need a keg in the middle to hide your coffee table, or it might be very big and absolutely clear.

Cook has ideas on how this will be dealt with. "The way we'll solve these problems, I believe, is by having procedural generation systems that are intelligent enough to redesign games to fit inside your room. So the game designer specifies what needs to be in this tavern – a bar, a table, a door – and then your HTC Vive automatically detects where these things should go.

"It generates the layout of the room to make sure you don't walk into that expensive vase you have in the corner, or accidentally put your knee through the TV. To me, VR is an amazing new environment to do procedural generation in."

"If you look at the stuff that gets put up on large YouTube Channels, it's things with a creative element, a procedural element, and also *Goat Simulator.* Procedural content gives you just enough hooks upon which a good storyteller can hang their own hat. I think that's something that *Minecraft* either got or stumbled upon – there's a certain level of crudity needed where you can then have a child just stick their imagination on it, and have something wonderful happen, and a lot of the people gunning in the same space have never really figured that one out. "

LIMINAL PROCEEDINGS

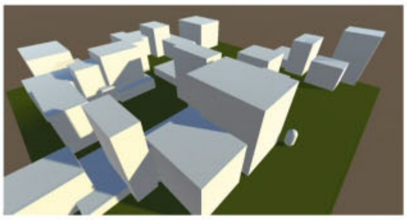
By contrast, Dr Tom Betts's motivations are less about speed or fame, and more about interesting outcomes. Dr Betts started as an arts student at Goldsmiths College in London. "I was really interested in the idea of creating systems that would make art work for me. I'd always been into computers and games so it made sense to combine those interests. I taught myself to program and I've been making generative and proc-gen software ever since." Dr Betts has created art, performed music and has been the lead programmer at indie games company Big Robot since 2008.

"I find it interesting that working with proc-gen is always a sort of collaboration between the programmer, the program code and the player. You can't dictate the outcome as precisely as you can in traditional production methods, and that makes it more interesting. Also, in terms of art and music, generative/proc-gen work has its own sort of aesthetic that comes from its ability to produce large numbers of variations on a theme, all of which are different, but maintain a shared style."

Several of Dr Betts's games have involved procedural generation. *Sir, Are You Being Hunted*, for example, uses a procedural system to generate all the terrain, housing, flora and fauna in its open world. "Procedural generation can aid the creation of all kinds of game world, especially in the case of large open-world games or anything with roguelike aspects. It can help smaller teams build larger environments and it can automate or assist many of the processes involved in larger studio production pipelines. We will undoubtedly see the usage of PCG tools and methods grow as games increase in complexity and production cost."

life: 065
ammo: 423

***.kkrieger* used procedural generation to shrink the game to just 96kb.**



Angelina generates entire games – though they can look quite plain.

INNER EXPLORATION

Cook has yet another motivation to use procedural generation – the reintroduction of genuine exploration to games. "*Minecraft* showed an entire generation of gamers how procedurally generated worlds could inspire a sense of discovery, exploration and awe – there are similar revolutions around the corner for generated game mechanics, generated stories, and so on. It's incredibly exciting." Part of that is there can be no walkthrough to a proc-gen world – at most, some recipes and best practice recommendations.

Cook is also interested in the development of aids to game development, which also come under the heading of procedural generation. "There's a lot of interest in building software that can help people design games, either by learning how humans design, or using a big database of rules. For example, imagine feeding every *Team Fortress 2* level into a machine-learning system, and then using that system to evaluate, comment on and even adjust levels designed by modders.

"The other big thrust is the automation of new areas of game design, moving out of the same old areas like dungeons and levels and looking into generating other, harder kinds of content. I'm really excited by this move – there are genres out there that we can't imagine right now because

SpeedTree can generate believable trees and foliage using mathematical formulae. It's been used in *The Witcher 3*, *Shadow of Mordor* and *Far Cry 4*, among many others.

DREAMS OF THE DEEP

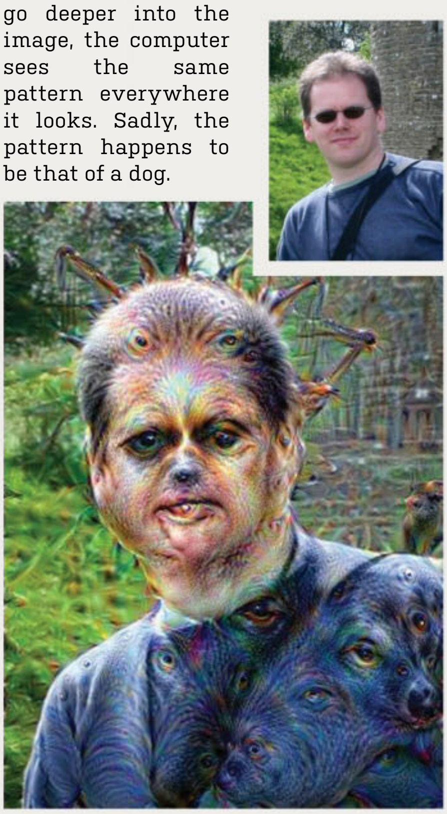
There are ways other than procedural generation and handcrafting to generate content. The most spectacular in recent weeks has been the frankly terrifying and hallucinatory images coming out of the Google Deep Dream project.

This project works by starting with a neural network. These are typically piles of 10–30 stacked layers of artificial neurons. The team starts training the neural network, using millions of examples, and then adjusts the network parameters gradually over time so that fidelity isn't lost, but random noise is.

Each layer of the network extracts higher level features than the previous one, until the final layer decides what the image looks like. So, the first level might detect edges, then intermediate layers might detect recognisable shapes, while the final layers assemble them into complete interpretations. This is exactly how Google Photo works, too.

The reason these horror pictures have been going around, of people with hundreds of dog's eyes making up their face, is that this particular neural network, called Deep Dream, has been fed data from ImageNet, a database of 14 million human-labelled images. But Google only uses a small sample of the database, which contained "fine-grained classification on 120 dog sub-classes".

It's the opposite of Mandelbrot's images. Instead of seeing the same pattern as we go deeper into the image, the computer sees the same pattern everywhere it looks. Sadly, the pattern happens to be that of a dog.



***PC Format* editor Alan Dexter gets the Google Deep Dream treatment. Yes, we're also scarred from this. We're off to scratch our eyes out.**

Jobs
Work Crews
Commodities
Factions
Menu

***Clockwork Empires* aims to become a more accessible *Dwarf Fortress*.**

we're waiting for new generators to come along and show us the way. Last month at a conference I saw systems which can generate metaphors, cocktails, dancers, fables and jokes. I'd love to see all of these things built into games, games that can generate new kinds of content beyond trees and rocks. I want games to write theme songs for my MMO character. I want games to write myths about my epic journey. I want games to procedurally generate me a best friend I can talk to. I want to see new things coming out of our computers."

BRIDGE OF SIZE

Vinings agrees, particularly when it comes to music. "Repetitive music drives me nuts; once you've listened to *Dungeons of Dredmor*'s entire soundtrack, good as it is, you've heard it all. We tried to modulate this in *Clockwork Empires* by having the soundtracks adjust themselves as your mood changed, and while it does work pretty well, it doesn't work as well as it could if we iterated on the technology for a few more rounds.

"The problem is that you have to have somebody who is a musician and a programmer, and you have to build tools. It's a very complex process that requires specific sorts of individuals. How do you teach a computer about orchestration?" Despite that, we have taught computers about things like image recognition (see "Dream of the Deep" on page 69).

One of the most interesting procedural generation benefits has to do with file size. Today we're growing accustomed to an endless increase in our computer's storage capacity – 1TB drives are now commonplace. But in areas of constraint, procedural generation can massively reduce file sizes, or eliminate the need for in-game assets completely.

When Naked Sky Entertainment's game *RoboBlitz* launched on PC and Xbox 360 in 2006, Microsoft had decided that the largest downloadable game it would allow on the system was a tiny 50MB, to fit on one of their (tiny for the time) memory sticks. Yet *RoboBlitz* was the first game to run the then-revolutionary Unreal 3 engine. As Naked Sky's chief technical officer Joshua Glazer told us, they used lots of tricks to get the game down to under 50MB – among them procedural generation.

***RoboBlitz* crammed the most technically advanced engine of its day into 50MB.**

***Minecraft*'s genius is in combining a procedural world with user customisation.**

"All those levels would have loaded a lot faster if it weren't for Microsoft's 50MB requirement, coupled with the requirement that we couldn't have any kind of 'install' process that unpacked the game after download," says Glazer. "We procedurally generated the textures for everything except Blitz (the hero) and the baddies. Pretty much every single square inch of the levels and most of the props were procedurally textured using Allegorithmic's cool procedural texture -gen tools. Also, all the animation was procedurally driven by physics. We also procedurally modified our sound effects on the fly so that we could get more use out of the samples we were able to squish in the package. The levels were not procedurally generated – we didn't experiment with that until our 2010 game, *Microbot*."

Naked Sky's latest game, *Scrapforce*, has mostly avoided procedural generation, save for an interesting-sounding stochastic AI system. And *RoboBlitz* isn't the smallest game made using procedural techniques – that prize almost certainly goes to *.kkrieger*, a 2004 first-person shooter that's only 96KB in size – but it is the most impressive for its size.

HARD LIMITATIONS

Despite all these positives, there are limits to procedural generation. Firstly, it can be processor intensive. *Dwarf Fortress* can take several minutes to get a game going, despite only displaying its graphics in ASCII. Gamers who are used to the rapid loading of mobile games might find this frustrating. And it's power-hungry too, as Cook explains. "If you're generating things like stories, or special abilities for an RPG, you want to know that they make sense, that they're balanced, that they're fun. That's an extremely difficult thing to test, and it often needs a lot of playtesting – and that means more computing power."

Another problem is that procedural generation works best in clearly delineated areas. Because it's so hard to define things like 'beauty' or 'fun', procedural generation often stays in areas where it knows it can perform. In those areas, it's commonplace. "Procedural art systems for trees and rocks are really popular – you probably don't even notice the games they're used in half the time," says Cook. "People don't really notice if a branch is slightly out of place, and trees follow quite clear natural rules that we can give to a computer, so it's a perfect use-case." For example, SpeedTree, the games industry standard tree generator, has appeared in nearly every AAA game for the last few years – *The Witcher 3*, *Shadow of Mordor*, *Destiny*, *Far Cry 4*...

Cook explains that when using "generative software in music, art or films, we mostly use it to target things where imperfections are hard to see (abstract art instead of portraiture), things that aren't the focus of attention (crowd scenes instead of big centrepieces), and preferably things where there are clear patterns and rules (I think electronic music benefits here)." Games, however, often allow procedural content to be closely scrutinised, increasing the quality threshold hugely.

This is not a photo, but an example of how real SpeedTree's tech can look.

> **"SpeedTree has been used in nearly every AAA game of the last few years."**

The game combining all these elements is *Dwarf Fortress*, currently the high point of procedurally generated games. "One of the strengths of *Dwarf Fortress* – a huge inspiration for *Clockwork Empires* – was that everything is procedurally generated," says Vining. "History, terrain, monsters, gods. The newer stuff in the upcoming *Dwarf Fortress* patch, with procedurally generated libraries full of procedurally generated books and poetic forms, is completely insane in the best way possible."

THE APEX

Developed by two brothers, Tarn and Zach Adams, *Dwarf Fortress* procedurally generates almost everything you could imagine. According to Tarn, in their previous game, *Slaves to Armok*, "you could zoom in on your character, and it'd tell you how curly his leg hairs were, and the melting and flash points of various materials. It was insane." *Dwarf Fortress* goes further.

The entire world and its history is generated, epoch by epoch, before you start playing, with kingdoms rising, dark gods falling, and magical items being lost for centuries. Then it generates the landscape and terrain you're in, the dwarves you're nominally in command of, the local flora and fauna, and a hundred other things, including art and poetry that references in-game events. *Dwarf Fortress* is so impressive and rigorous, but also insane, that people have built working computers inside it. That's right, a virtual machine running inside a game.

Michael Cook's Angelina simulation can't claim to be as complex as *Dwarf Fortress*, but it's increasing comprehensiveness in a different direction. That's because Angelina (www.gamesbyangelina.org) is an experiment in computers designing and evaluating video games autonomously. "The games Angelina produces aren't procedural," he explains. "All the generation happens during the design of the game, but Angelina releases static games like you or I might if we made a game. It's all about how we can procedurally generate a game design, ideas, art, mechanics, music and put it all together, rather than generating what happens in the player's computer when they're playing."

ANGEL WITH A BROKEN WING

"Angelina is interested in generating everything in a game, which means we have to tackle the hardest problems for procedural generation, like aesthetics and emotions, as well as the more rule-based stuff like generating mazes and rocks. I want Angelina to generate program code, and game mechanics, and systems of meaning so it can tell you a story with its games or make you think."

These two types of comprehensiveness – *Dwarf Fortress*'s obsessive inclusiveness and Angelina's procedural game design – are core to the story here. Games, and their successor, VR (see "Generating Escapism, page 68), are a universal experience. They can contain everything else in the world, so they take in every other part of generative art, if everything's not to be handcrafted at great expense. The only way to do that, without us all becoming developers, is procedural generation. ■

Sir, You Are Being Hunted used procedural generation to accurately replicate the British countryside... most of the time.

PROC-GEN MEDIA

Fiction book: Life, A User's Manual
Written by Georges Perec, in line with the Oulipo manifesto, this book isn't strictly speaking programmatic, but Perec wrote it in line with formulaic constraints that meant he had to write about a certain room, in a certain building, with certain people and objects interacting in every chapter. Perhaps because of that, it comes across as a weird jigsaw puzzle of a book. And somewhat long-winded.

Fact book: Philip M Parker
Professor Philip M Parker has patented a method that automatically produces books from a set template, which is then filled with data from internet searches. He claims to have produced over 200,000 books, ranging from medical science to dictionaries about just one word, with most of them being print-on-demand only… he's also started generating factual books for under-served languages, in collaboration with the Bill & Melinda Gates Foundation.

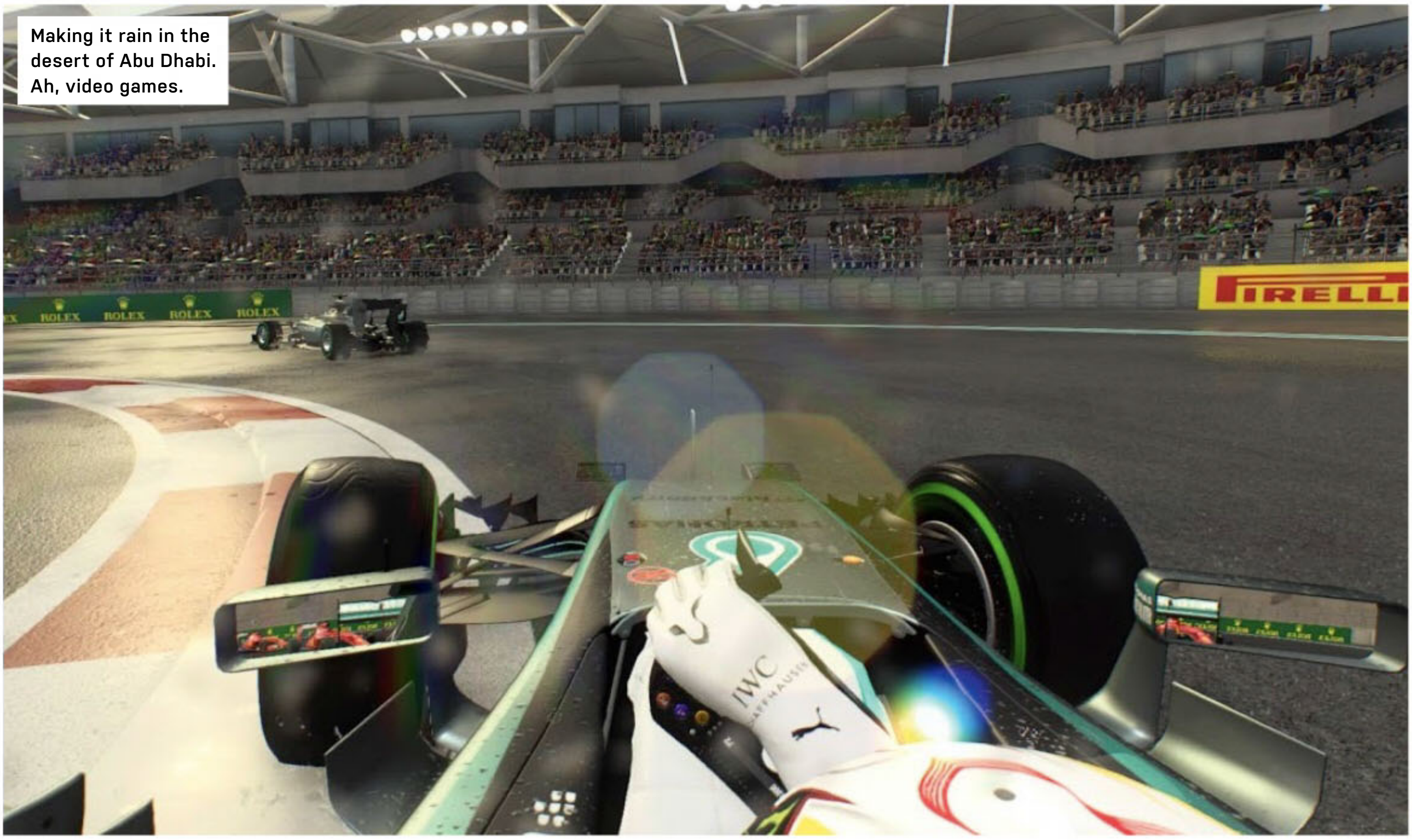
Music: Brian Eno
Back in 1996, Brian Eno used Intermorphic's SSEYO Koan software to create his album *Generative Music 1*, which was in fact a piece of software itself. The music ran off a floppy disk and 'improvised' within the 150 parameters that Eno had set to create a different track every time. He's continued to experiment throughout his life.

Film: WETA and Massive
The huge armies in the conversion of Tolkien's trilogy were generated by a collaboration between WETA and a special effects company called Massive that could create convincing representations of thousands of actors – if you didn't look too closely and noticed that they all looked like Andy Serkis (joke).

Cartoon: Toy Story 3

It might seem old-school now, but *Toy Story 3* used a ton of groundbreaking procedural generation techniques to animate large-scale scenes. The scene where the toys find themselves in a garbage incinerator? Most of the trash was procedurally generated from the other trash around it. Similarly, the plastic bags wafting through the wasteland and how Barbie tore up Ken's vintage clothing collection.

Art: No Man's Sky
Yes, it's a game, but Hello Games's *No Man's Sky* plans to procedurally generate an entire universe, from the flora and fauna, to the planets and stars. Then it generates alien landscapes and lets you land on them and walk about. Amazing.



Making it rain in the desert of Abu Dhabi. Ah, video games.

F1 2015

Bareboned and inconsistent, but it's F1 at its purest

SPORTS FRANCHISES ARE WEIRD. We want realism and authenticity; the most accurate representation of any given year in a league or championship. But we also want excitement and new stuff to play with.

It must be a struggle to provide the two, especially when the only innovations in F1 are often banal regulations, the addition of a virtual safety car, or – at best – a brand new circuit. This year, Codemasters has seemingly given up trying, removing almost everything but the barebones of a career mode and some online multiplayer options. Surprisingly enough, *F1 2015* also represents the purest and most thrillingly breakneck representation of F1 yet.

There's no longer the option to create your own racer and take him from Zero to Hero in seven years. Instead, it's just one season playing as an already-established driver. Without the option to create your own driver and start at the bottom, the progression element that dominated the first few seasons of a lengthy career is lessened considerably. But the racing is far more immersive without the extra faff to distract you – no emails to sift through. no team contract offers to ponder.

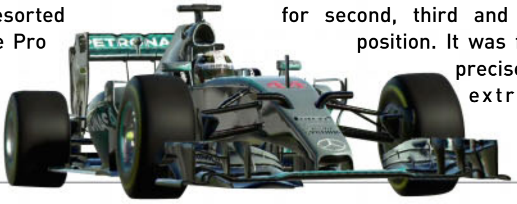
With so little new to actually shout about, Codemasters has resorted to calling out features like Pro Season – a championship mode in which all the assists are turned off, the AI difficulty is at its hardest setting and you're restricted to cockpit view for entire races. While this kind of thing feels a little disingenuous to pitch as something new when you could essentially create these kinds of conditions in previous games, *F1 2015*'s graphical improvements and the major changes to its handling model are notable. There's a vibrancy that was previously lacking. Monte Carlo feels suitably flash and the night sky of Singapore is appropriately black, dazzled with neon lights.

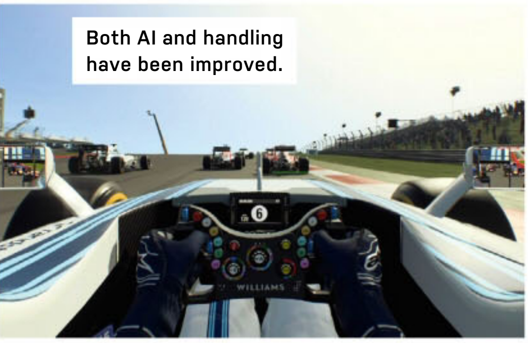
QUALITY CONTROL

Our favourite part about the *F1* games has always been the feeling of unknown as you head into a long race, and that's even stronger here. Sure, you can set up a handful of three or five-lap races if you're short on time, but the 25 per cent length is where the game really hits its stride. On a 50 per cent race in the dry, driving Vettel's red Ferrari, we were pulling out a decent gap in second, managing our tyres effectively. When the first stint of pit stops came around, we lost our advantage and ended up in a 10 to 15-lap tussle with Massa and Rosberg, all of us vying for second, third and fourth position. It was frantic, precise and extremely tense. None of it was for first position, but every last point felt extremely important, and as our tyres began to wear and the grip levels dropped, it got really close.

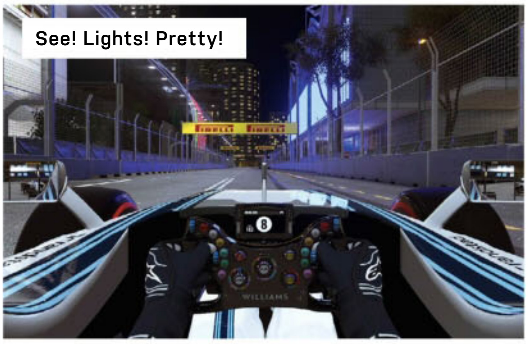
Your new race engineer, Jeff, gives you a lot more information as you race, even advising how you're dealing with tyre wear. Sadly, there's no safety car feature, which makes racing incidents a little unnatural, as a huge pile-up can occur into the first turn, only to have green-flagged racing conditions resumed by turn three. Opponent AI, however, have been improved alongside the game's handling. They're defensive when you're on the chase, and aggressive as soon as they get the jump on you, utilising DRS to pull off any passes they can. It can be frustrating when the game's penalty system dishes out unfair punishments for an AI mistake, but the unlimited flashbacks option lets you replay any incidents to avoid that.

The best way to play is at the toughest setting you can handle. Our preference is with opponent AI on Legend, braking assist and ABS turned off, and with traction control turned on. With a pad, this feels the most challenging, satisfying way to play. Codemasters has greatly improved the sense of torque in the rear wheels, and you can really feel the power of the back end as you exit a sharp turn. Snapping the wheel back quickly is essential to avoid a spin.

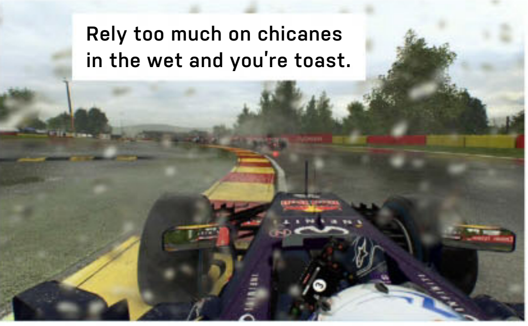




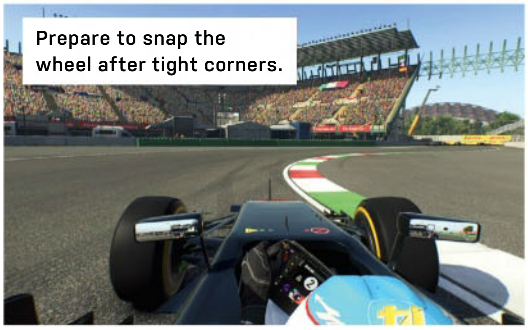
Both AI and handling have been improved.



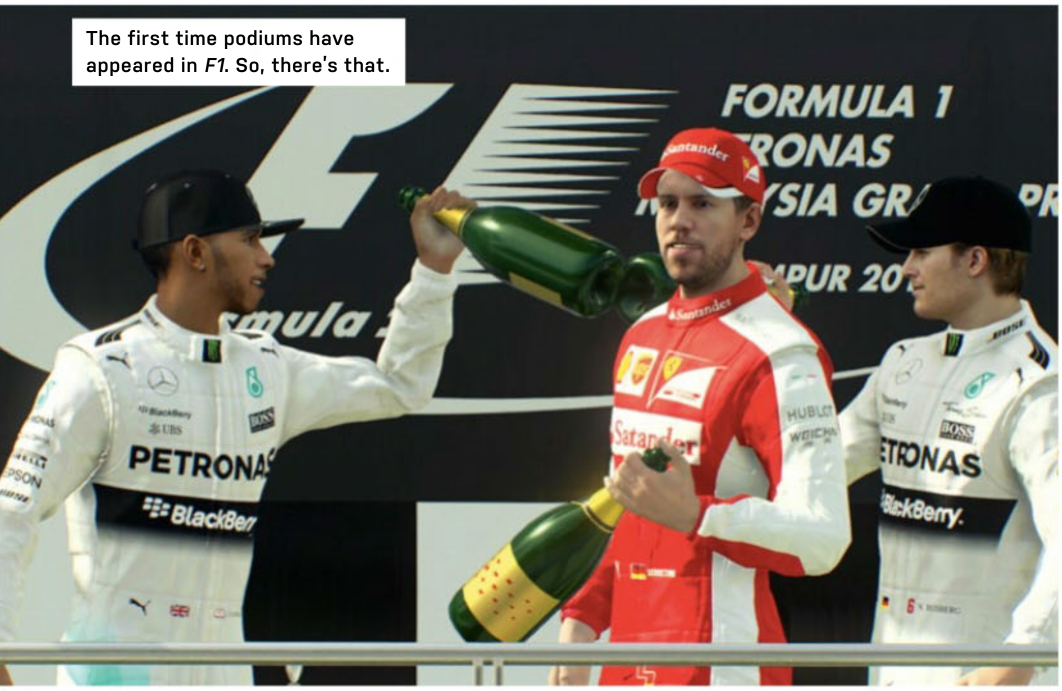
See! Lights! Pretty!



Rely too much on chicanes in the wet and you're toast.



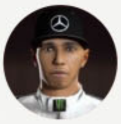
Prepare to snap the wheel after tight corners.



The first time podiums have appeared in *F1*. So, there's that.

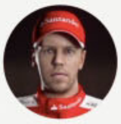
ON THE GRID

The pace-setters you'll need to beat on the track

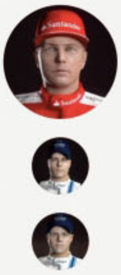


Lewis Hamilton
This year's dominant big-dog, Lewis Hamilton leads the championship by a fair margin thanks to a number of stylish victories. Lewis is fast and merciless on the track, and getting past him won't be an easy task.

Nico Rosberg
Everyone's favourite sulky German, Nico Rosberg came close to overtaking Hamilton in the standings a couple of times. Rosberg is clearly a talent, but most of the time runs a reluctant second. He'll still be a nightmare to pass.



Sebastian Vettel
Four-time consecutive world champion with Red Bull and now at Ferrari, Vettel isn't having a bad debut season with the Italian reds. He's running in a comfortable third, but the German is pushing hard to regain his victory streak.



Kimi Raikonnen/Williams
The battle for fourth, fifth and sixth in the drivers championship is separated by only three points at the moment. Ferrari's Iceman and the Williams duo of Bottas and Massa each have the skills necessary to take the top spot. The Williams renaissance is impressive, and they're a force to be reckoned with.

Other than the single championship, Pro Season and Quick Race options, there's little else. The Time Trial leaderboards return in identical form, and online multiplayer represents the only way to play with friends, as Codemasters has culled the split-screen options. At the time of review, Online options are temperamental at best, and broken at worst.

AIN'T NO REVOLUTION

Codemasters has divided racing into preset tiers of difficulty, with assists and other settings differing, depending on what difficulty you've selected. We've managed to find a couple of games throughout our time playing, but the majority of the time we're met with a failed-to-find-match message. Hopefully this gets sorted in patches, as for now it's questionable.

We've also seen a lot of negative reviews on Steam about game stability, with control pad issues and game crashes. We've only experienced three crashes to desktop during our 10-or-so hours with the game. These are frustrating, especially if you're 20 or 30 laps into a race, but game instability is not nearly as prevalent as we were expecting. Frame rate has been an almost rock-solid 60fps, dipping infrequently on the run to first corner, when there's an especially large pile-up, or when the rain is absolutely hammering it down.

The most disappointing aspect of *F1 2015* is that it just doesn't look that impressive when stacked up against the likes of *Project Cars*. You've a raft of options at your disposal, from anti-aliasing and anisotropic filtering to all manner of reflections, shadows and weather effects, but it's not a graphical powerhouse.

With so little new, it's tough to unreservedly recommend *F1*. It's the best representation of F1 racing to date, but it's also not the revolution that Codemasters promised when it essentially admitted *F1 2014* was a stopgap. After four years at the wheel, playing each game extensively, we thought we might be bored of racing the same tracks, but *F1 2015* surprised us. We haven't had this much fun with the series since *F1 2011*, despite its inexcusable lack of content, unstable multiplayer suite and unchanged foundations. Sports franchises are weird. –SAM WHITE

VERDICT 7

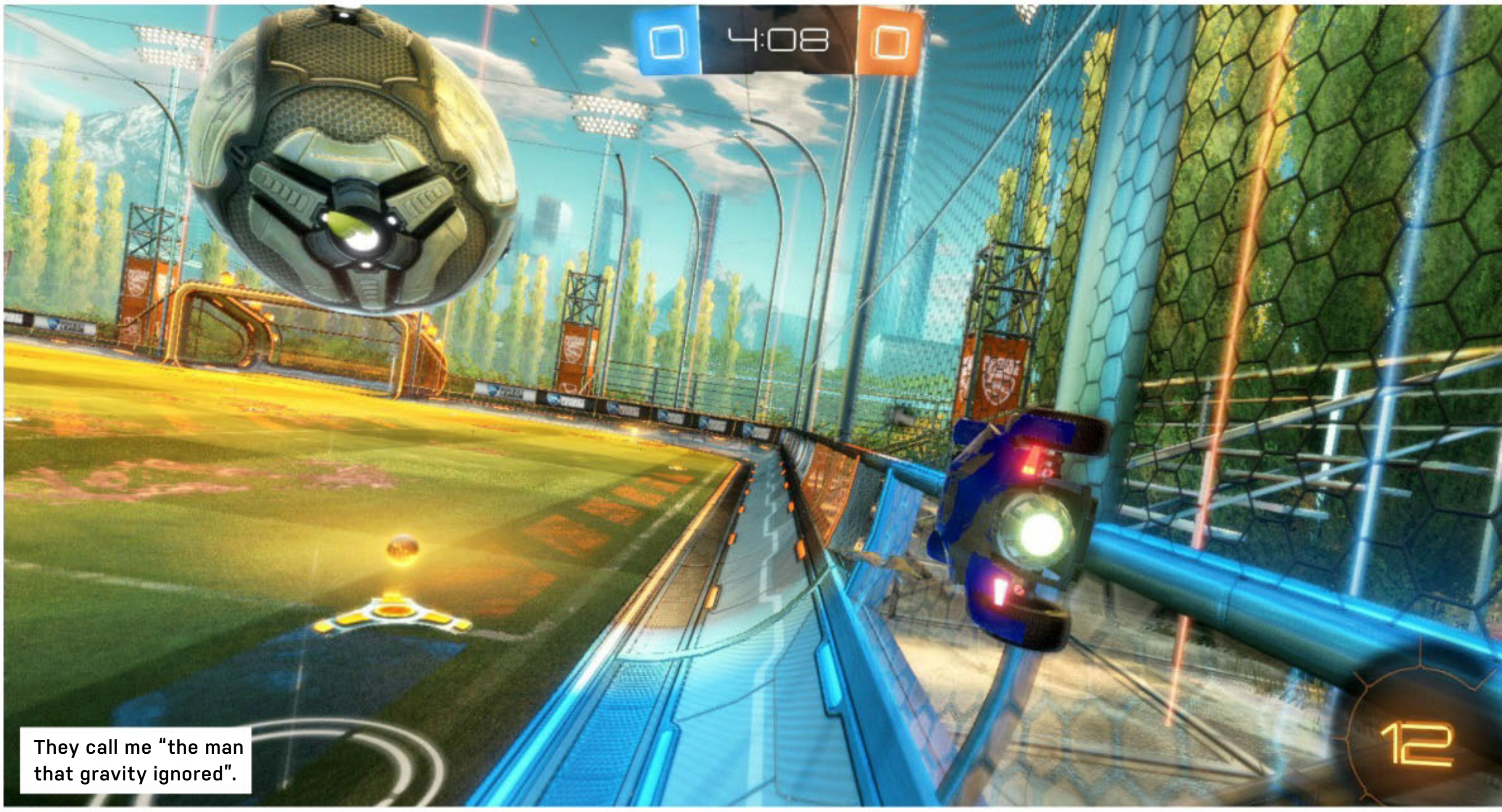
F1 2015

+ CHEQUERED FLAG Thrilling handling; improved AI.

– CHEQUERED PAST Too little content; online issues; not the best-looking.

RECOMMENDED SPECS Core i7-4770 / FX 9370; GTX 970 / R9 290; 8GB RAM.

£40, www.formula1-game.com, PEGI: 3



They call me "the man that gravity ignored".

Rocket League

Cars and football, for people who care about neither

LET'S NOT WASTE ENERGY exploring why football should replace its paper chain of squalid billionaires with cars, and accept it as fact. A fact that *Rocket League* proves with simple and immediate ease. Yes, this is a game about cars playing football. That's as developed a plot as you'll require.

We've never played a game that needed a tutorial less. Drive car at giant ball; hit ball into net; score points. *Rocket League*'s competitive core has existed for millennia, and this helps make a preposterous concept feel primal. This, in turn, is a laughable way of describing a game that would be called moto carball if it actually existed in real life.

Like dry martinis and penises scribbled in unattended notebooks, *Rocket League* is a celebration of distinction through simplicity. Driving is delicious. Cars ease around like butter in a heated pan, but always feel under control. You accumulate boost by driving over markers, and unleashing it is a thunderous rush, firing you across, over and around the pitch. Matches take place in smooth, enclosed spaces, so you can drive up walls and over ceilings as a shimmer of perpetual motion.

Cars can also jump and dodge, which can be used defensively and offensively. The weight of the cars, as well as your ability to apply boost to jumps, adds a pleasingly haphazard element; something like athletic footballers leaping above the opposition to header high balls, but with zero chance of flattening a £2,000 hairdo.

The vehicles feel light and buzzy – somewhere between *Micro Machines* and those slidey remote-controlled cars that only seem to appear on Christmas Day. This contrasts nicely with the fat, beefy bounce of the ball, which gormlessly invites impact like a punchable cousin. And that's it. We almost feel guilty reducing a review to 'ball' and 'car', but there are only ever those two things in the field of play, and crucially, they both feel great.

There are no weapons, but certain markers fill your boost and let you obliterate other players. Mercifully, it's the generous, instantly respawning type of obliteration. Destruction is the only conspicuous deviation from the clean and simple business of driving around and scoring goals, but in most of the games we played, it was a rarity, and certainly never frequent enough to be irritating.

SIMPLE PLEASURES

Alternatively, you can set teams of four against each other, in matches that become so frantic that they're less like footy and more like a lost, confused beach ball bashed between bumper cars. Playlists of duels, doubles, standard 3v3 matches and the appropriately named Chaos 4v4 mode are all available online, with ranked playlists limited to duels, doubles and 3v3.

There's a reason why online play is the first option on the menu, as here's a game that feels designed to be played with actual people, and this is absolutely where it thrives. We rarely had to wait long for a game, and if players dropped out mid-session they were immediately replaced by AI bots. Best of all, it's refreshingly simple to get back into another game, so very little time is spent lingering in lobbies.

If playing online isn't your thing, there are exhibition matches and full seasons you can do solo. The length and difficulty can be altered, and while it doesn't offer much depth – cars and football, remember – we still found ourselves bonding with pretend teammates. Perhaps we're lonely.

The offline modes do reveal the game's minor inadequacies, however. Team AI can be flaccid and unreliable, especially against tougher opponents, and the same simplicity that makes *Rocket League* so playable can cause things to get repetitive when played alone; a criticism that only becomes apparent precisely because it's so damn addictive. It's a simple thing done brilliantly well, kept interesting by the thrill of competition. –MATT ELLIOTT

VERDICT 9

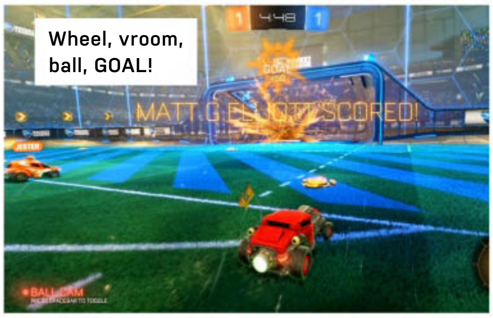
Rocket League

⊞ THROUGH ON GOAL Fast, fun, simple; relentlessly enjoyable; best football game without feet.

⊟ ON THE DOLE Unreliable AI teammates; simplicity can make it repetitive.

RECOMMENDED SPECS 2.0+ GHz quad-core CPU, Nvidia 260 series graphics; 4GB RAM.

£15, www.psyonix.com, PEGI: NR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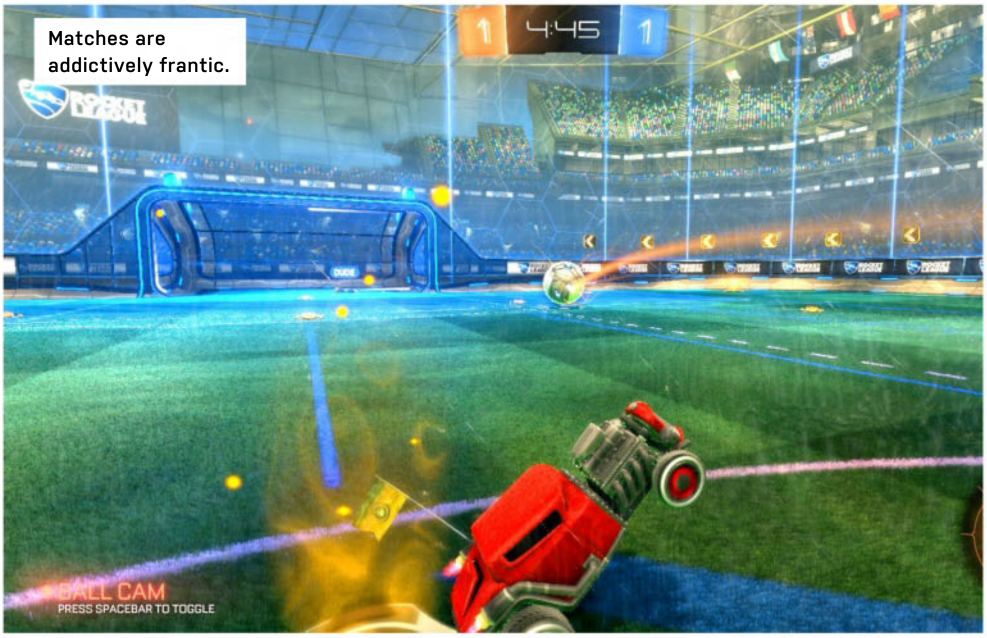
MATT.G ELLIOTT SCORED!
BALL CAM

Wheel, vroom, ball, GOAL!

DECAL
SKULLS

You can tinker with unlockable goodies in the garage.


1
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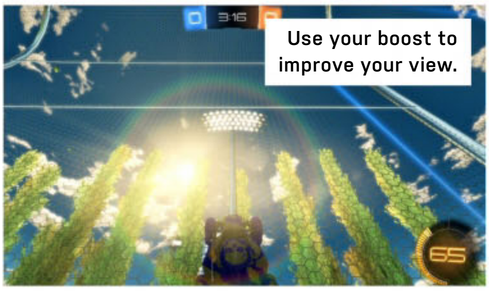
1
ROCKET LEAGUE
BALL CAM
PRESS SPACEBAR TO TOGGLE

Matches are addictively frantic.

There's no time to admire the scenery.

There's the ball. Go hit it. Plot done.



Use your boost to improve your view.

Games take place in giant cages – more gaol than goal.

NUTMEGS AND BOLTS

Five silky skills every MVP should master

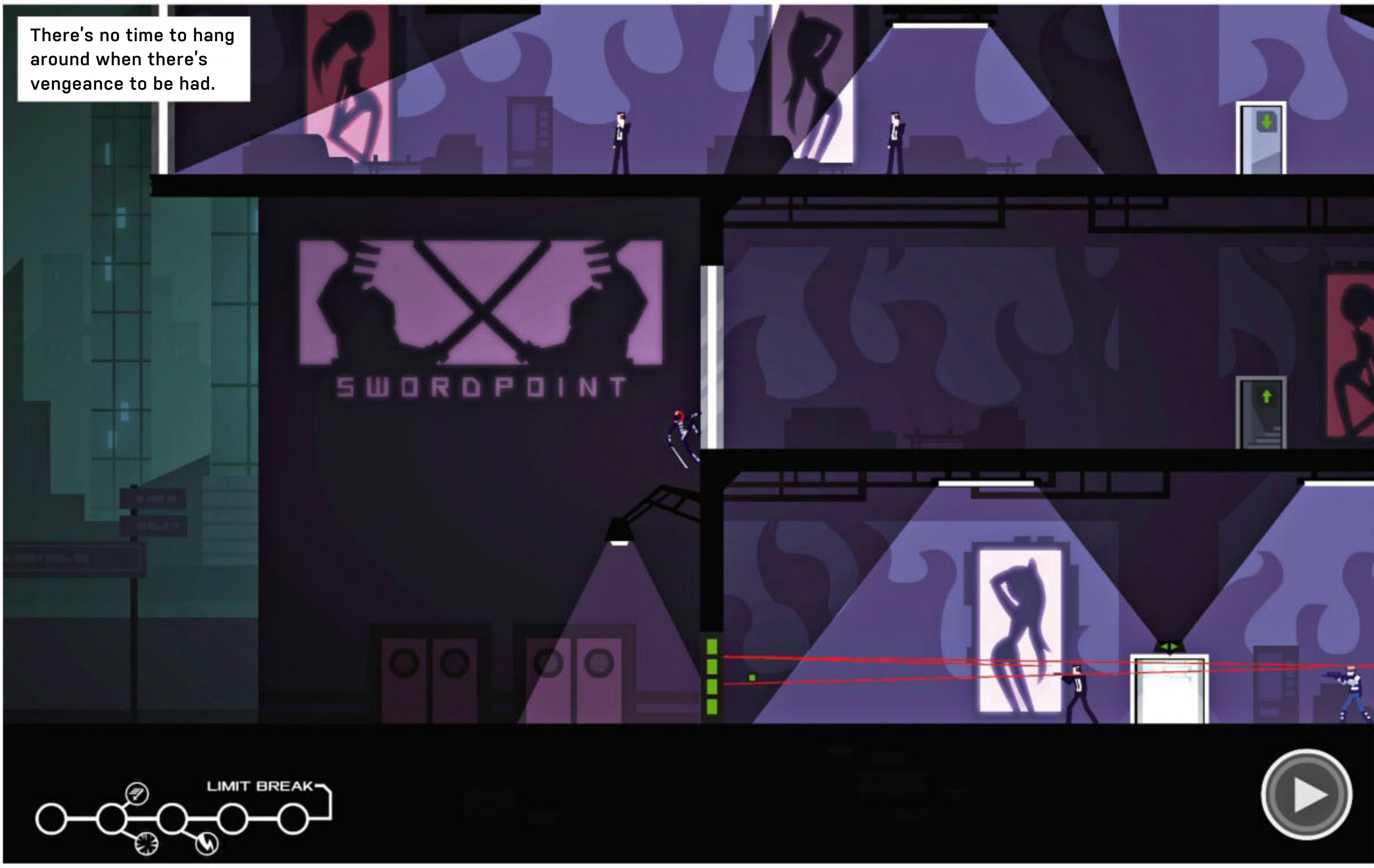
1 Boost Helps you to whack the ball with some vigour, but also allows for excellent mid-air acrobatics when applied during a jump.

2 Jump Hop up to hit high balls, or block lobbed balls. Press twice for a probably impossible double jump. Heck, it's all impossible!

3 Dodge Flip forwards, sideways and backwards for an extra boost of momentum, which will send the ball flying.

4 Slide Powerslide around the arena to change direction easily and knock shots sideways. Also: looks cooler than disco cucumbers.

5 Ram Fill your boost meter and slam into an enemy vehicle, destroying them utterly. It's not even a cardable offence.



There's no time to hang around when there's vengeance to be had.

Ronin

A mixture of stealth and turn-based combat, which isn't quite as good as its obvious inspirations

WHY YES, *Ronin* does look a lot like *Gunpoint*. A 2D action-stealth game that takes place in the interiors of a stylishly futuristic city, its similarities are numerous. You hack computer terminals, use the mouse to plan and execute jumps, and stick to any wall or ceiling you fling yourself against. *Ronin* is less derivative than it first appears, though, thanks largely to the prominence of the combat.

It looks like a stealth game and sometimes plays like a stealth game, but there are frequent occasions where you're forced into battle. *Ronin* is first and foremost about fighting, and the turn-based swordplay is what distances it from its most visible source of inspiration.

Each of its five chapters has three levels: two in which you infiltrate buildings to hack terminals, and a third where you confront and kill one of the five executives responsible for the death of your father. Set in sprawling office buildings, each level is composed of a number of self-contained sections. At first, you're unseen – free to lurk in the darkness, taking out guards and planning your opening strike. But soon you'll need to jump into the light, at which point the action pauses. Each combat turn is defined by the enemy's actions. If a red laser sight is pointed at you, on the next turn they'll fire. If they've fired, on the next turn they'll re-aim.

The trick is to always be moving. It takes two turns to down a guard: one to land near them, and one to strike them down. It takes two turns in the same position to get yourself killed. That's the central puzzle of each encounter. The easiest solution is to jump directly onto the guards, knocking them down and giving yourself a couple of turns before they recover.

At a basic level it's an enjoyable system to manipulate, enhanced by unlockable skills. These are tied to a limit break meter that builds as you stun and kill. Fill it completely, and you're given a free action. More often, it's worth spending your accrued points on a potentially life-saving special move. By the end of the game, we could create decoys, throw our sword, and send out a circle of daggers that temporarily downed all visible guards.

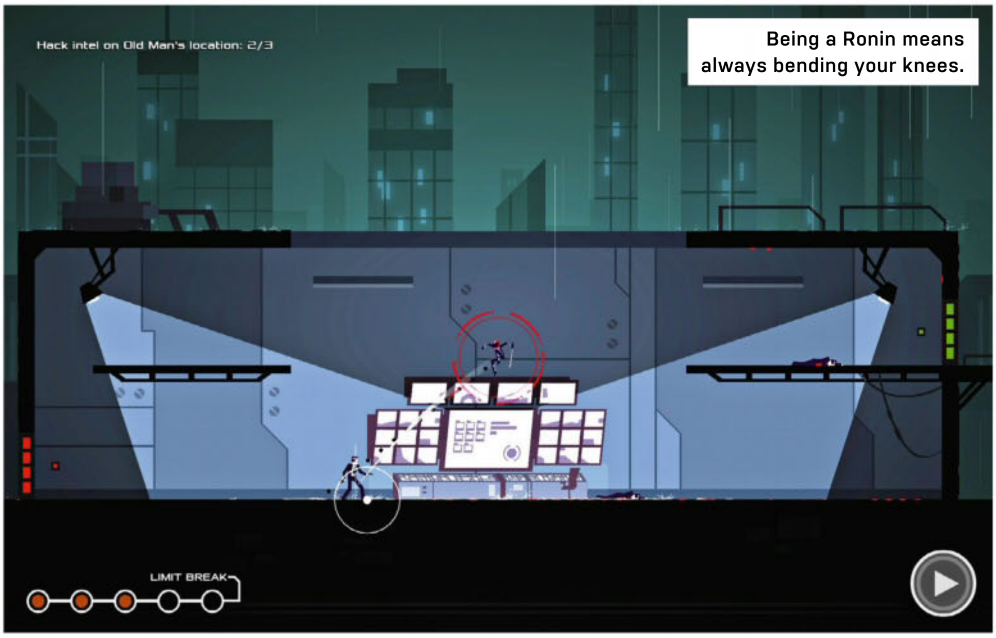
There's even a teleport move that lets you instantly slam into any visible enemy to send them flying. If they're standing by a window, this works as an instant defenestration button.

As we grew more familiar with the combat, inconsistencies became more apparent. For starters, you don't always have enough information to plan a move. The jump tracer doesn't account for enemies, so it's difficult to know where you'll end your turn if you go for a stun – an omission that led to our death on more than one occasion. *Invisible, Inc.* proved the worth of complete transparency in turn-based feedback, and it's a lesson we wish *Ronin* had learned.

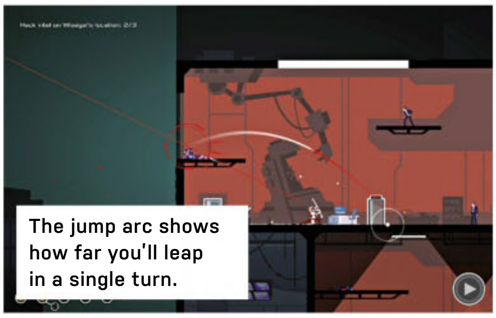
RONIN ON THE SPOT

More frustratingly, your combat moveset is restricted. You can't climb or run, only jump, and you're unable to fine-tune actions mid-turn. Outside of combat, you can pause at any moment to plan and execute moves. We suspect the limitations are a necessary tradeoff to keep the difficulty intact, but they seem to undercut the game's core fantasy of balletic, fluid action expressed through stop-and-start systems.

Each level has three optional objectives: don't kill a civilian, don't trigger a lockdown, kill all guards. Except, they're not really optional. You need to complete all three to earn a skill point used to unlock

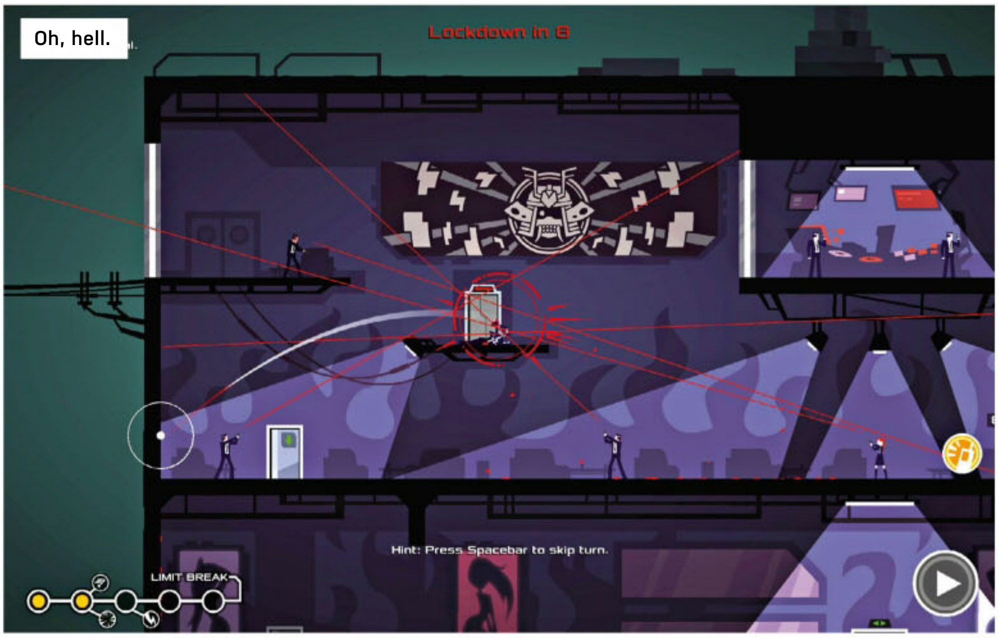

Hack intel on Old Man's location: 2/3
Being a Ronin means always bending your knees.
LIMIT BREAK

The trick is to keep moving.
LIMIT BREAK


The jump arc shows how far you'll leap in a single turn.

His one weakness? Windows.
LIMIT BREAK

See. Look at the knees. Bent.
LIMIT BREAK


Oh, hell.
Lockdown in 8
Hint: Press Spacebar to skip turn.
LIMIT BREAK

Ronin's best toys, and that means you're incentivised to re-try each checkpoint over and over. With a growing collection of skills, *Ronin* stays interesting. The level design is largely excellent, offering plenty of varied scenarios, albeit only a handful of enemy types.

It ultimately doesn't live up to the quality of its inspirations, but then it doesn't really need to. It does enough to make for a fun four-to-six hour campaign of gratifying swordplay. –PHIL SAVAGE

VERDICT 7

Ronin

SAMURAI A fun, if lightweight, stealth combat game; well-designed; good unlockable skills.

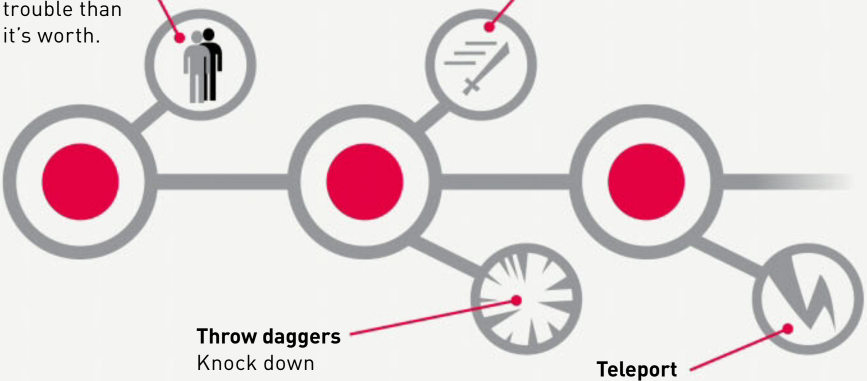
SAMWISE GAMGEE The turn-based fighting isn't perfect; restrictive moveset; enemy types are a bit limited.

RECOMMENDED SPECS Intel Core Duo or faster, 2GB RAM

£10, www.bit.ly/1LD7uS1, PEGI: NR

PUSH IT TO THE LIMIT

Ronin's skills explained



Holographic decoy More trouble than it's worth.

Throw sword Remember to get it back again.

Throw daggers Knock down everything.

Teleport If enemy is near a window, use this.

T3

HELPING YOU MAKE THE MOST OF LIFE IN TODAY'S CONNECTED WORLD

ONLINE • PRINT • TABLET

AUDIO TECHNICA ATH-MSR7
Escape to a world of high resolution audio

SAMSUNG JS9000
Relax with the latest home entertainment

CARL ZEISS VR
Embrace a new era of virtual reality gaming

SONY XPERIA Z3
Putting you in control of your life and home

APPLE WATCH
Your health and fitness upgraded

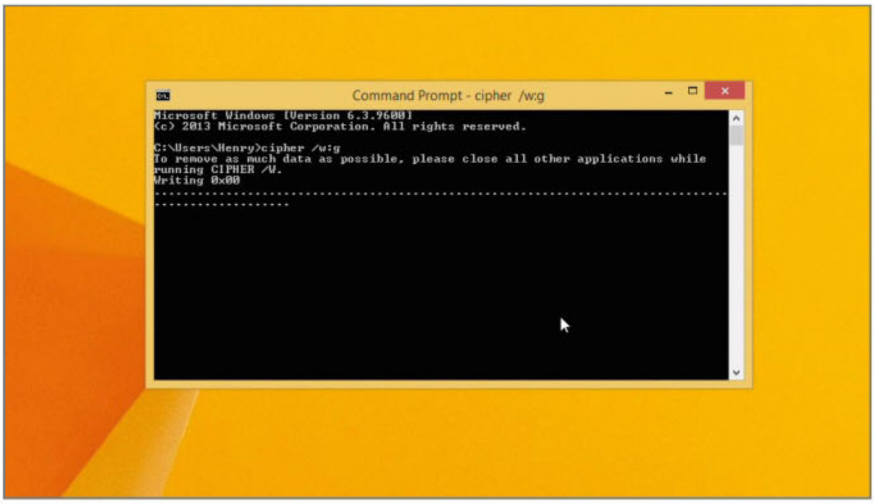
LIFE'S BETTER WITH T3

t3.com

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH



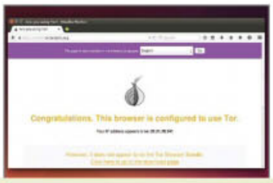
```
Microsoft Windows [Version 6.3.9600]
(c) 2013 Microsoft Corporation. All rights reserved.

C:\Users\Henry>cipher /w:g
To remove as much data as possible, please close all other applications while
running CIPHER /W.
Writing 0x00
................................................................................
...................
```

SCRUB DRIVES WITH CIPHER

Selling your computer or its disks? This Windows tool ensures they're squeaky clean by securely deleting files by overwriting them, rather than just removing the index. Cipher is simple to use via Command Prompt – type 'cmd' and hit [Enter]. Next, type 'cipher /w:x:', where 'x' is the letter of the drive you wish to empty. Close other apps to speed up the process.

MAKE – USE – CREATE

80
Build a NASA-inspired mini-PC



84
Set up a Tor network on a Pi 2

88
Run Win10 on a virtual machine

ANDREW WESTBROOK
PRODUCTION EDITOR

THE KEY TO SUCCESS

So, everyone updated to Windows 10? Happy? Loving it? Good. But have you gone all the way and given yourself the freshest start possible? I'm referring, of course, to the hassle of doing a clean install, an experience that generally ranks alongside tax returns in the get-your-pulse-racing thrill stakes. And Windows 10, bless it, has proved to be little different. If you've been putting it off, I don't blame you.

But whether you're just upgrading your current OS or have a sexy new Windows 10 PC, no doubt stacked with bloatware, it's always worth starting afresh. There's just one or two more hoops to jump through. For starters, you'll still have to go through the upgrade process first, starting out with a fresh install of Windows 7 or Windows 8, depending on which OS you started out with. Once that's done, you then need to update to Windows 10 using the Windows update tool, so that your PC is properly registered.

At some point in the process, Windows will need to access your product key. Don't worry though, you won't have to start scurrying around the back of your PC, scrambling through drawers or trawling through endless emails trying to find it. This is because Windows stores that all-important 25-digit product key in the UEFI firmware these days. Which has the rather worrying knock-on effect that your copy of Windows 10 is tied to your motherboard. Upgrade it, and you'll need to buy yourself a new copy of Windows. Or call Microsoft support.

↘ submit your How To project ideas to: pcfmail@futurenet.com

BUILD IT

BY ALEX CAMPBELL

Rocket Science

We aim for the stars with a NASA-inspired, rocket-fuelled, miniature powerhouse

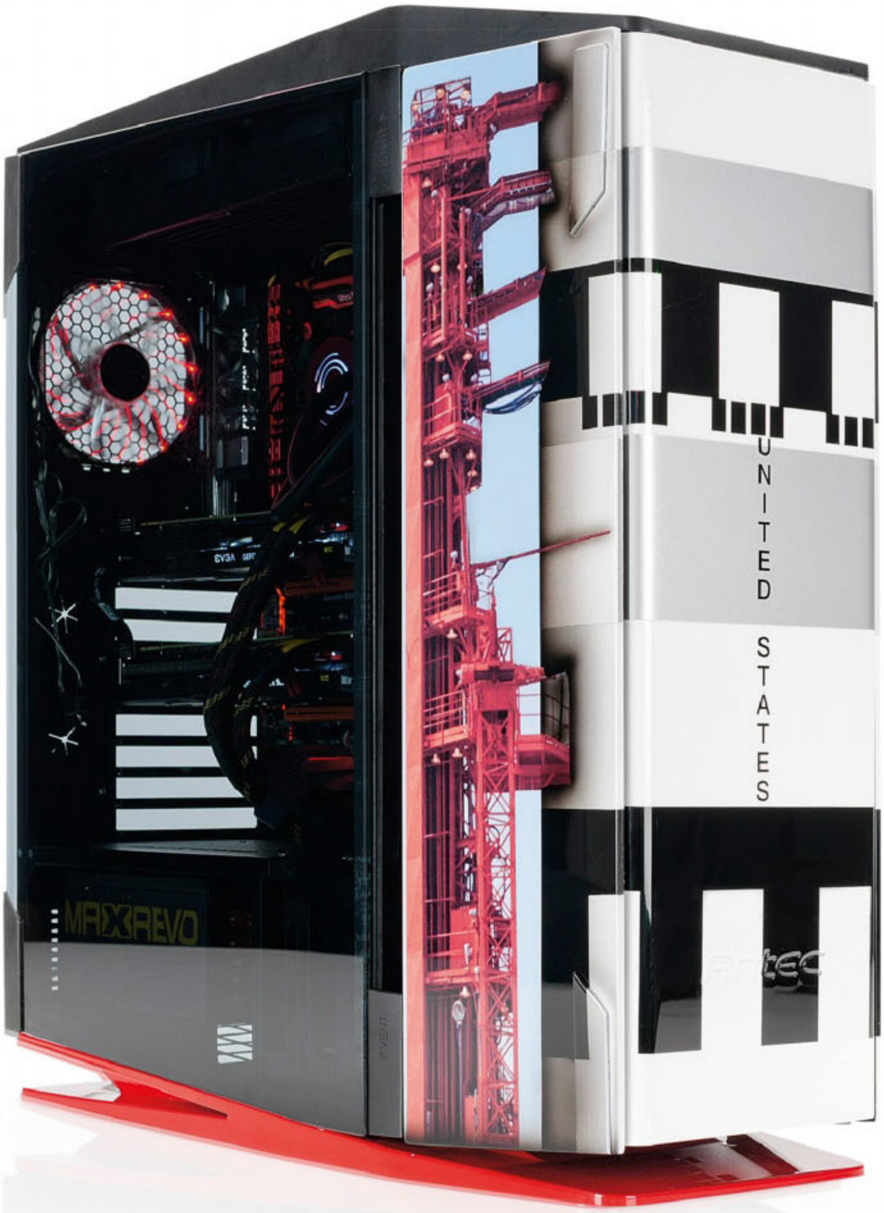
LENGTH OF TIME: **1–3 HOURS** | LEVEL OF DIFFICULTY: **MEDIUM TO CHALLENGING**

THE FLIGHT PLAN

WHEN YOU'RE BUILDING a machine from scratch, compromises tend to hold you back from piecing together your perfect PC. Cost, if nothing else, is usually the limiting factor. But what if you don't have to compromise? What if, this time, you can build your dream PC? That's what we've done this issue; we've shot for the Moon. We've even themed it accordingly – going for a NASA finish that hints at the high-end components contained within.

The components you'll find in this rig are basically what we consider to be at the top of their game. We haven't completely ignored the price – you can easily spend more if you so wish – but we've tried to focus on the kit that matters. Why drop silly money on a Titan X, for example, when the GTX 980 Ti is almost its twin in most games. This is a dream machine, don't forget, so we haven't limited ourselves to just one graphics card – two GTX 980 Ti's will give you a great return for your money and will handle today's games at eye-straining resolutions and settings.

We've also overclocked the rig. High-end components tend to give you that little bit more room in the performance stakes, so it'd be remiss of us to not use the extra bit of power. And that additional push from the overclocking should just give us enough thrust to leave the atmosphere.



VEHICLE ASSEMBLY

THIS IS A NASA-INSPIRED BUILD, so we had our prototype Antec S10 case sent off to Smooth Creations to have it custom-painted to replicate a 1960s Titan II Gemini Launch Vehicle. We went with a Core i7-5930K CPU. It's two cores lighter than the 5960X, but friendlier to overclocks and your wallet – the 5960X is nearly £400 more, a hefty £200 per extra core. We got a nice stable overclock with our 5930K, bumping it to 4.5GHz from the stock 3.5GHz with the help of 1.31 volts. We kept the main engine cool with an NZXT Kraken X61.

The GPUs are a pair of EVGA GTX 980 Ti Superclocked ACXs in SLI. We overclocked these already factory-overclocked rockets further, adding 150MHz to the core clocks and 300MHz to the memory clocks using EVGA's PrecisionX software. We powered the overclock with an overvolt of 31mV. We used 16GB of 2,800MHz DDR4 memory in a kit of four 4GB modules. We ran into problems at 2,800MHz, so underclocked to 2,666MHz for stability. We probably could've overclocked the RAM a bit and reached 3,000MHz, but we didn't go looking for a RAM overclock; the timings on these modules are plenty fast.

For storage, we put the 1TB SSDs in RAID 0 for the OS, and kept the 6TB spinning drives in reserve. We mounted all of these goodies onto Gigabyte's X99 SOC Champion mobo, which has more overclocking options than we knew what to do with. We powered our ship with an 80-Plus Gold-certified Enermax 1,350W Maxrevo modular PSU.

INGREDIENTS

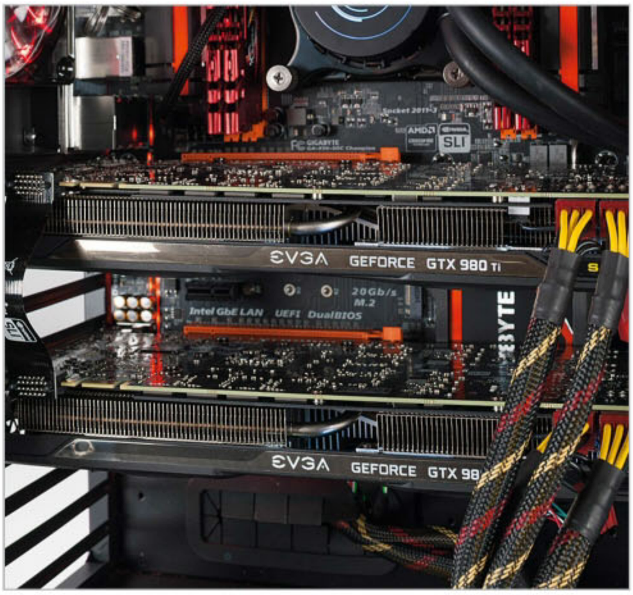
PART		PRICE
Case	Antec S10 Prototype Custom	£320
Motherboard	Gigabyte GA-X99-SOC Champion	£211
CPU	Intel Core i7-5930K	£410
Memory	G.Skill Ripjaws 4 Series 16GB 2800 DDR4	£120
GPU	2x EVGA GeForce GTX 980 Ti SC ACX 2.0	£1,120
PSU	Enermax Maxrevo 1,350W	£268
HDD	2x Western Digital 6TB	£420
SSD	2x Samsung 850 Pro 1TB	£720
CPU cooler	NZXT Kraken X61	£100
Fans	3x EK Vardar F4 120mm 2,200rpm fans	£51
Total		£3,740

1

BOOSTER IGNITION

THE PAIR OF 980 Ti'S that we used really push this machine into the ionosphere. The main thing to keep in mind is that they're air cooled. Maintaining good airflow was a top priority when we went into the realms of overclocking. Luckily, the SOC Champion's PCIe x16 slots are numbered (from top to bottom) 1, 4, 2, 3. That means that for the best performance, we had to put the second GPU in the third slot from the top. This gave us a nice gap where air could flow freely, in comparison to the 2–5mm it would have if the cards were in adjacent slots.

We also upped the fan speeds in PrecisionX to 90–100 per cent when we were searching for a stable overclock. To be sure, there was a lot of air flowing around these two cards. If you look closely, you'll see that spacing these cards further apart means that you can add an M.2 SSD if you prefer storage speed over a potential third GPU.

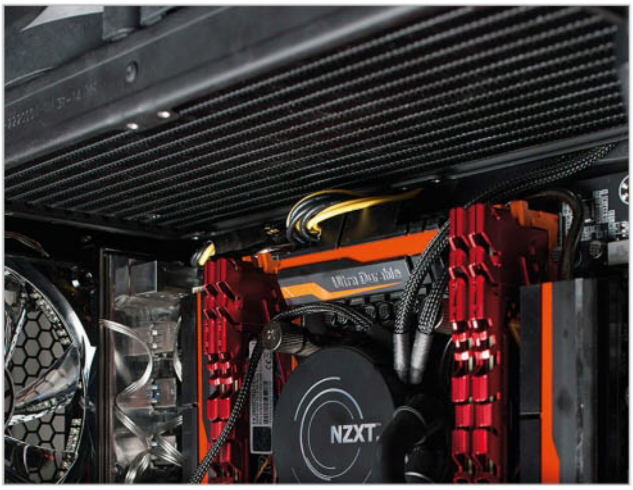


2

CRAMPED QUARTERS

SPACESHIPS AREN'T EXACTLY ROOMY. Engineers cram the most equipment into the tiniest space available to save on weight and profile. This machine was no different. When we attached the Kraken to the top mounting bracket, we had to really push the bracket into place, smashing the CPU power cables a bit. It's secured by two thumbscrews, and lining up those screw holes was a test of mettle and patience.

We could then place intake fans to the front of the main compartment to pull in lots of air for our GPUs. We could've gone with a smaller closed-loop cooler, but we wanted that performance. The X61 kept our CPU at a cool 25°C at idle, and at 57°C under a 90 per cent load, running our Premiere Pro CS6 benchmark.

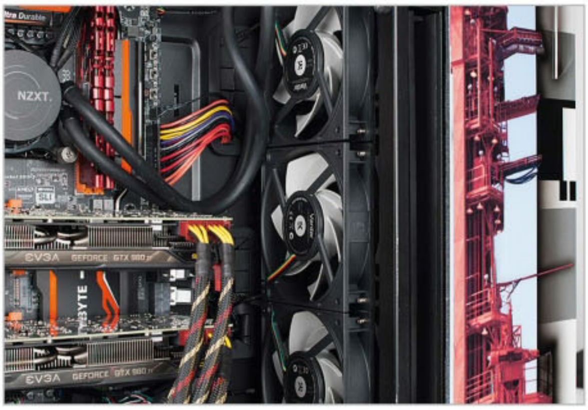


3

AUXILIARY THRUSTERS

ATTACHING OUR X61 allowed us to mount three fans up front to draw in air. We chose a trio of EK's Vardar 120mm static pressure fans. These babies spin at 2,200rpm and push 131 cubic metres per hour). We hooked up the top fan to the CPU PWM fan connector (our X61 is hooked into CPU_OPT), and the bottom two to the X61's two spare connectors. It's worth noting the retail S10 has a PWM fan hub on the back of the motherboard tray, so doing things this way wouldn't be required.

For benchmarking, we cranked up the power to get air flowing over the 980 Ti's. Boy, did that air flow. Between these three fans and the two Krakens up top, we could feel the positive pressure escaping through little gaps in the doors. The S10 also features a removable filter on the outside of the main compartments, in front of the fans. A tab near the base of the S10 releases the filter for removal.

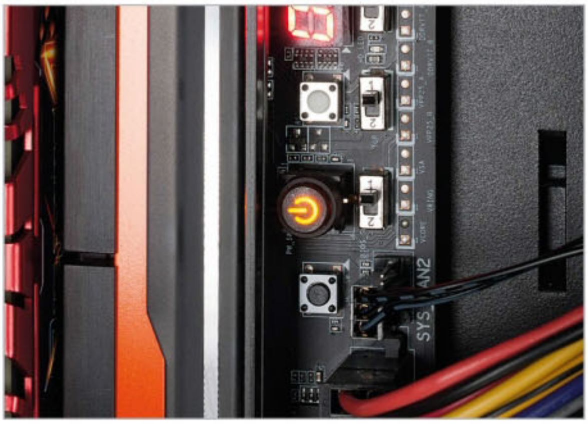


4

MANUAL IGNITION

WHEN WE WERE FIRST PLAYING with this case, we accidentally pulled the front-panel wires loose of the panel buttons and LEDs. Whoops. Luckily, this motherboard comes with a power button on the board itself. Many modern motherboards feature a power button, and they come in handy for things besides compensating for screw-ups – for example, if you're building on a test bed or want to test a particular feature without connecting the front-panel buttons.

There are also buttons to reset the BIOS to defaults, and a toggle that switches to the backup BIOS as well. That sounds trivial, but when you're using all the overclocking features this mobo has to offer, messing up is very possible. Having an easy way to switch to an alternate BIOS or reset to defaults is a good move for tinkerers and overclockers who want to push limits.

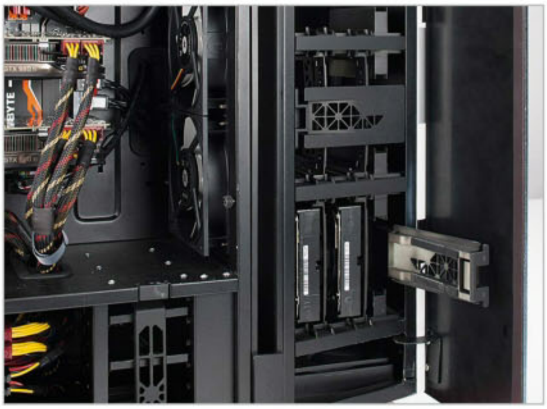


5

OPEN THE POD BAY DOORS, HAL

ONE OF THE THINGS that will first catch your eye is the S10's separate tower for hard drives. It seems excessive, but it has a real-world purpose: keeping the ambient temperature of the main compartment low. The tower's doors swing open in the front and rear of the case, making installation easy. The slots for the toolless brackets are rubberised, so drive vibration is absorbed, resulting in longer drive life and less sound from platters spinning at 7,200 RPM.

Our pair of 6TB drives were happy, kept plenty cool by a dedicated fan. The fan draws air from under the tower and pushes it up, across the surfaces of the vertically mounted drives. We hooked this fan to the SYS_FAN3 PWM fan header on our mobo, and set the speed to maximum. It stayed quiet at that speed.

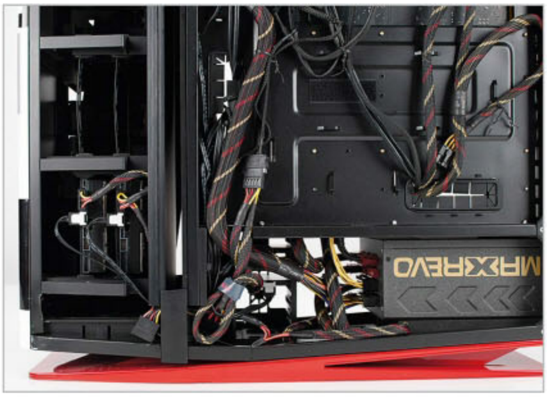


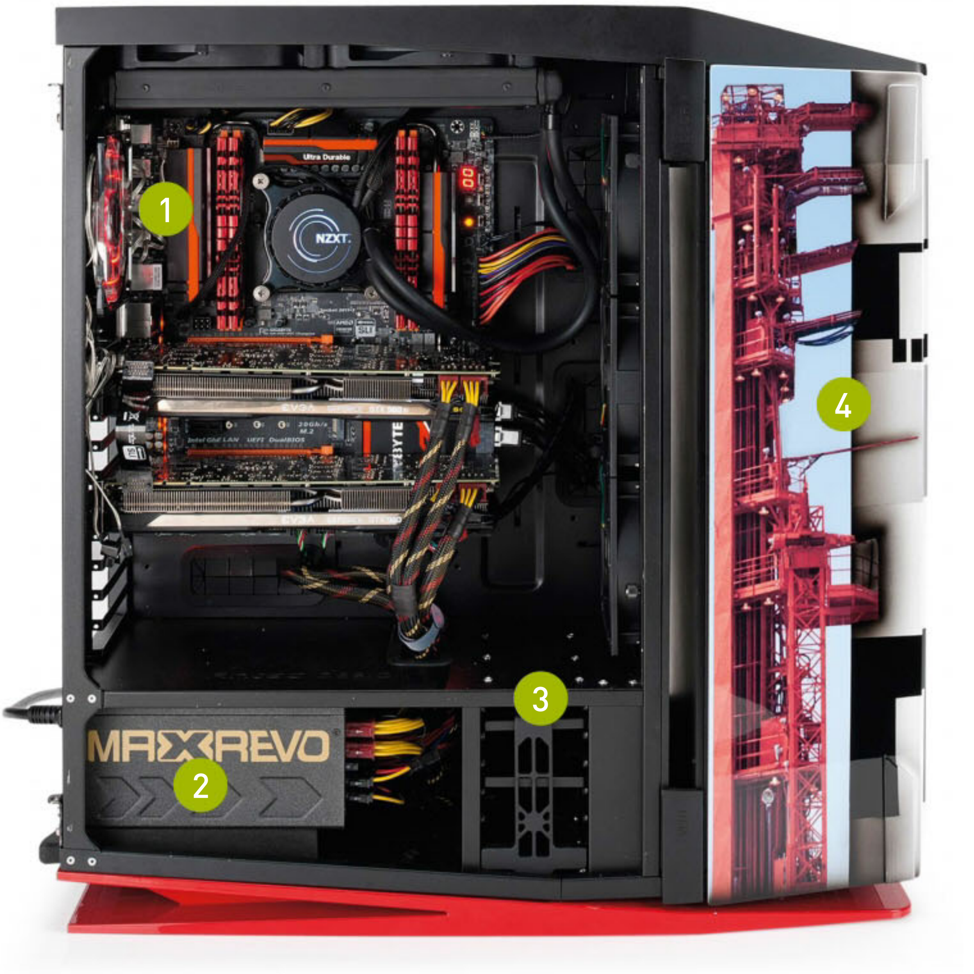
6

CONTROL CONDUITS

WE DON'T OFTEN show cable management in our builds. It's not always pretty. But there's good reason to this time. The first thing to notice is how SATA power and data cables get into the hard-drive tower. A tab at the bottom of the case can be released. But this tab covers the cable pass-through, where all your SATA cables must go. We positioned the WD drives on the bottom row to stay within our cables' reach.

Also note that if you want a clean case, the rest of the system's power must snake through a fairly small cutout, requiring long PSU cables. In our build, only the ATX cable was long enough to get where it needed to go. For the CPU power, we had to route through the floor grommet into the main compartment, back out the grommet under the mobo, and then back in through the grommet above the mobo.





1. This red LED-lit fan came with our power supply. While it uses a typical PWM fan connector, it also has a manual dial for fan speed and a switch to turn the lights on and off.

2. The 1,350W Maxrevo power supply gives us much more power than we need for this build. On the upside, it leaves more than enough headroom for overclocking and adding in more graphics cards.

3. The 2.5-inch drive cage in the PSU compartment sits right next to a fan, which helps keep SSDs (or 2.5-inch HDDs) cool.

4. The custom paint job by Smooth Creations really made this case a star. The retail case comes with tinted glass doors instead.

RE-ENTRY AND SPLASHDOWN

AT £3,740, this orbital overclocker is plenty pricey, but delivers dreamy performance. This ship is essentially a tier above what we achieve in our high-end build in "Rig Builder", which includes a screen (see page 52).

We had a lot of fun building into this case, which was a prototype that needed a refinement here or there. Even with minor shortcomings, the case presents well, has good airflow in all of the parts that matter, and even had room for our beefy Kraken X61 – though it meant a little pushing and shoving to get everything to align. Many of the issues we had have since been addressed and fixed in the production-line case.

When we ran our benchmarks, we really saw the kind of performance the GTX 980 Ti offers with its 6GB of VRAM. The fact that we used factory-overclocked models that we then overclocked some more paid dividends in the frame rate department.

The triple GTX 980 SLI setup in our beefy test rig was outgunned by the higher VRAM that the GTX 980 Ti's were packing. Given that a trio of reference GTX 980s cost £1,170 (at £390 each), the pair of GTX 980 Ti's, at £1,120 (£560 each), provides the greater value. Sometimes two really is greater than three.

That performance comes at the cost of power though: Reference GTX 980 Ti's draw 250 watts, or 85W more than the plain-old 980 reference cards do. Though that's still less power than the 275W the Radeon Fury X draws. The difference isn't much for this build – two 980 Ti's will put you just 5W over a trio of 980s, which draw 165W each.

The i7-5930K served us well. A hearty overclocker, it got us to a similar clockspeed as our test rig, with its 5960X, despite being short two cores. Two cores are a big deal, but with such a huge price difference, the 5930K really delivers bang for your buck.

We could have saved a lot of coin on the hard drives, if that was a motivation, since the lower-capacity WD drives are far more affordable than their 6TB brethren. Likewise, builders pay a premium for a 1TB SSD. Opting for 250GB or 500GB models could save hundreds, which could go towards a third 980 Ti, a third SSD for a three-drive RAID array or a bunch of games on Steam.

All in all, we're very happy with this build, and had a great time assembling it. While still priced at a premium, we feel this mini–rocket reaches for the stars, while not being too unattainable. ■

BENCHMARKS

	TEST RIG	
Stitch.Efx 2.0 (sec)	806	558
ProShow Producer 5.0 (sec)	1,472	1,163
x264 HD 5.0 (fps)	33.8	28.5 (-15.7%)
Batman: Arkham City 1440p (fps)	204	238
Tomb Raider 2160p (fps)	87.5	101.3
Shadow of Mordor 2160p (fps)	70.1	105.4
3DMark FireStrike Ultra	8,016	8,378

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop test rig PC uses a 5960X CPU, three GTX 980s and 16GB of RAM. *Arkham City* tested at 2560 x 1440 Max settings with PhysX off. *Tomb Raider* at Ultimate settings. *Shadow of Mordor* at Max settings.

Set Up a Tor Network on a Raspberry Pi 2

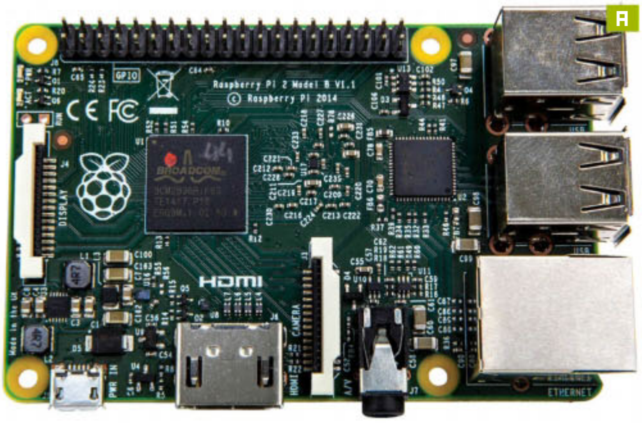
YOU'LL NEED THIS

RASPBERRY PI 2
The brilliant mini-computer costs less than £30. See www.raspberrypi.org.

MICRO SD CARD
You'll need a blank card to hold Raspian, the Pi OS.

DO YOU USE TOR to prevent Big Brother tracking you online? If so, you'll know that while straightforward to use, it can be a hassle to configure Tor on all of your internet-enabled devices. You can save yourself a lot of hassle by using a Raspberry Pi as an anonymised wireless access point. The Pi will dole out an IP address and then any device that's connected will be able to access the web via the Tor network.

To get this up and running, you'll need a Raspberry Pi, along with an SD card with the Raspbian distro. You'll also need an Ethernet cable. Hook one end into the Pi's Ethernet port and the other into your wireless router. This is how the Pi will connect to the internet. You'll also need a USB Wi-Fi adaptor that's compatible with the Raspberry Pi. If you haven't got one of those yet, check out the list of compatible adaptors that are known to work on the Pi – you can find that here: http://elinux.org/RPi_USB_Wi-Fi_Adapters. –MAYANK SHARMA



1 ACCESS POINT PI

Once you've set up your Raspberry Pi [Image A] – see our September issue for detailed instructions – you can configure it from a remote machine via SSH. For the rest of the tutorial, we'll assume the IP address of your Pi is 192.168.2.100. Fire up a terminal that's connected to the same router as the Pi and enter

```
ssh pi@192.168.2.100
```

to connect to it. After authenticating yourself into the Pi, use

```
iwconfig
```

to make sure the wireless adaptor is recognised by the device. Now refresh its package list with

```
sudo apt-get update
```

and install the software that will make it start to act as an access point with:

```
sudo apt-get install hostapd isc-dhcp-server
```

» When it's installed, it's time to set it up. Begin by editing the '/etc/dhcp/dhcpd.conf' file that controls the DHCP and automatically assigns IP addresses to all connected devices. Open it in the nano text editor with

```
sudo nano /etc/dhcp/dhcpd.conf
```

and comment out the following two lines by adding a "#" in front of them, so that they read:

```
#option domain-name "example.org";
#option domain-name-servers ns1.example.org, ns2.example.
org;
```

In the same file, scroll down and uncomment the word "authoritative"; by removing the "#" in front.

Then scroll down to the end of the file and add the following lines:

```
subnet 192.168.12.0 netmask 255.255.255.0 {
range 192.168.12.5 192.168.12.50;
option broadcast-address 192.168.12.255;
option routers 192.168.12.1;
default-lease-time 600;
max-lease-time 7200;
option domain-name "local";
option domain-name-servers 8.8.8.8, 8.8.4.4;
}
```

In these lines we define the IP address of our Pi access point (192.168.12.1), the range of the IP addresses it'll hand out to connected devices (from 192.168.12.5 to 192.168.12.50), as well as the address of the domain name servers (8.8.8.8 and 8.8.4.4). You can change any of these values as per your preference. Hit [Ctrl]–[X] to save the file once you're done.

2 SETTING UP A STATIC IP

We'll now edit the '/etc/default/isc-dhcp-server' to specify the interfaces that our new DHCP server should listen to. Open the file and scroll down to the line that reads "INTERFACES=""". Insert "wlan0" between the quotes so that it now reads "INTERFACES="wlan0"", and save the file.

» Now we'll set up the wireless adaptor (wlan0) and give it a static IP address. First, deactivate the wireless adaptor with:

```
sudo ifdown wlan0
```

Then open the '/etc/network/interfaces' file. In the file, remove every existing entry associated with "wlan0", such as the following:

```
# iface wlan0 inet manual
# wpa-roam /etc/wpa_supplicant/wpa_supplicant.conf
# iface default inet dhcp
```

Then add the following lines below the line that reads "allow-hotplug wlan0" to set the static IP address for the new access point:

```
iface wlan0 inet static
address 192.168.12.1
netmask 255.255.255.0
```

Save the file and activate the interface with

```
sudo ifconfig wlan0 192.168.12.1
```

3 MAKE YOUR POINT

Now that we've defined the wireless access point it's time to configure it. Create a new file called '/etc/hostapd/hostapd.conf' with the following contents:

```
interface=wlan0
```

```
ssid=TorSpot
hw_mode=g
channel=6
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_passphrase=$$Your_Passphrase$$
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP
rsn_pairwise=CCMP
```

We've set up a password-protected network called 'TorSpot'. You can specify a different name for the access point by specifying it in the 'ssid=' string. Also change the 'wpa_passphrase=' string to specify a custom password. You'll need to enter this password to authenticate yourself to the Pi's access point.

» Next up, we'll tell the Pi where to find this configuration file by pointing to it in the '/etc/default/hostapd' file. Open the file, find the commented outline that reads "#DAEMON_CONF=""" and uncomment and edit it to read "DAEMON_CONF="/etc/hostapd/hostapd.conf"".

4

NAT SETUP

We now need to set up NAT to allow multiple clients to connect to the Pi's access point and route all their traffic through the single Ethernet IP. Edit the '/etc/sysctl.conf' file and at the bottom add the following line:

```
net.ipv4.ip_forward=1
```

Save the file and then enter

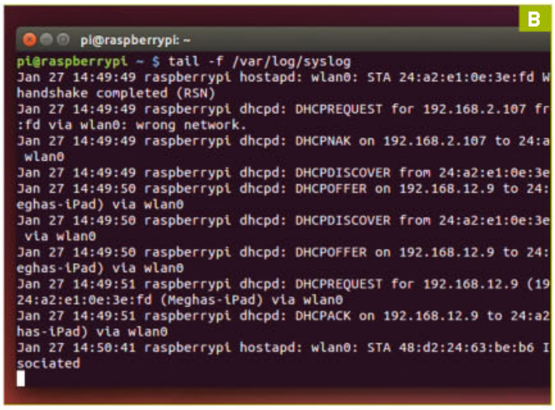
```
sudo sh -c "echo 1 → /proc/sys/net/ipv4/ip_forward"
```

to activate the forwarding. You'll now have to specify the routing rules that will connect the Ethernet port (eth0) that's connected to the internet and the Wi-Fi access point (wlan0), which is exposed to the devices within your network:

```
sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
sudo iptables -A FORWARD -i eth0 -o wlan0 -m state --state
RELATED,ESTABLISHED -j ACCEPT
sudo iptables -A FORWARD -i wlan0 -o eth0 -j ACCEPT
```

By default, these rules will be flushed when you restart the Pi. To make them permanent, first run:

```
sudo sh -c "iptables-save → /etc/iptables.ipv4.nat"
```


B

```
pi@raspberrypi ~ $ tail -f /var/log/syslog
Jan 27 14:49:49 raspberrypi hostapd: wlan0: STA 24:a2:e1:0e:3e:fd W
handshake completed (RSN)
Jan 27 14:49:49 raspberrypi dhcpd: DHCPREQUEST for 192.168.2.107 fr
:fd via wlan0: wrong network.
Jan 27 14:49:49 raspberrypi dhcpd: DHCPNAK on 192.168.2.107 to 24:a
 wlan0
Jan 27 14:49:49 raspberrypi dhcpd: DHCPDISCOVER from 24:a2:e1:0e:3e
Jan 27 14:49:50 raspberrypi dhcpd: DHCPOFFER on 192.168.12.9 to 24:
eghas-iPad) via wlan0
Jan 27 14:49:50 raspberrypi dhcpd: DHCPDISCOVER from 24:a2:e1:0e:3e
 via wlan0
Jan 27 14:49:50 raspberrypi dhcpd: DHCPOFFER on 192.168.12.9 to 24:
eghas-iPad) via wlan0
Jan 27 14:49:51 raspberrypi dhcpd: DHCPREQUEST for 192.168.12.9 (19
24:a2:e1:0e:3e:fd (Meghas-iPad) via wlan0
Jan 27 14:49:51 raspberrypi dhcpd: DHCPACK on 192.168.12.9 to 24:a2
has-iPad) via wlan0
Jan 27 14:50:41 raspberrypi hostapd: wlan0: STA 48:d2:24:63:be:b6 I
sociated
```

Then edit the '/etc/network/interfaces' file. Scroll down to the very end and add:

```
up iptables-restore ← /etc/iptables.ipv4.nat
```

This will load the rules when the devices are activated on boot.

» Your Pi access point is now all set. To test it, restart the DHCP server with

```
sudo service isc-dhcp-server restart
```

and manually enable the access point with our configuration with the following command [Refer to the "Your Own Hostapd" box, below, if you get an unknown driver error]:

```
sudo /usr/sbin/hostapd /etc/hostapd/hostapd.conf
```

If everything goes well, the wireless access point (TorSpot) is listed in the list of available Wi-Fi hotspots. You can connect to it from another computer or a smartphone and authenticate using the password you specified in the 'hostapd.conf' file. When connected, you should be able to browse the internet normally.

» Once you've tested the new access point, let's cement the settings so they're activated as soon as the Pi boots. Start the hostapd and DHCP services with the command:

```
sudo service hostapd start
```

Then use:

```
sudo service isc-dhcp-server start
```

Update the init scripts with:

```
sudo update-rc.d hostapd enable
```

And finally:

```
sudo update-rc.d isc-dhcp-server enable
```

YOUR OWN HOSTAPD

Sometimes, even though a wireless adaptor works out of the box on the Raspberry Pi, it might throw errors when it's asked to serve as an access point. This is especially true of cards that use Realtek chipsets, like the one we've used – MicroNext MN-WD152B – which uses the RTL8192CU chipset. While it works right off the bat for browsing the web, it doesn't work with the hostapd client in Raspbian's repository. Apparently, Realtek has its own version of hostapd client, which you'll have to use if you're in the same predicament as us.

To download the file, you'll need to head to Realtek's download section (http://bit.ly/RealtekWiFiDrivers) and select your chipset. This takes you to a page that lists the drivers for your chipsets. From this page, grab the driver for Linux, which will download a compressed zip file with a long-winded name. We'll just refer to it as driver.zip.

Copy this file to the Raspberry Pi using "scp", using something like:

```
scp driver.zip pi@192.168.2.100:/home/pi
```

This copies the file to the Pi's home directory. Now extract the file with:

```
unzip driver.zip
```

and cd into the 'wpa_supplicant_hostapd' directory. It'll list several compressed tarballs. Use the "tar zxvf" command to extract the file beginning with 'wpa_supplicant_hostapd'. Now, cd into the hostapd directory under the extract directory. This directory has a file named 'Makefile'. Open it in a text editor and replace the:

```
CFLAGS = -MMD -O2 -Wall -g
```

line towards the top of the file with:

```
CFLAGS=-MMD -Os -Wall -g
```

Save the file and enter "make" to compile the hostapd client. It'll take quite some time. When it's complete, it'll replace the hostapd binary in this directory. Before using this new version, move out the old version with:

```
sudo mv /usr/sbin/hostapd /usr/sbin/hostapd.orig
```

Then copy over the newly compiled version with the following:

```
sudo cp hostapd /usr/sbin/
```

And give it the right permissions with:

```
sudo chmod 755 /usr/sbin/hostapd
```

You should now be able to get your access point online without any issues.

Now restart the Pi with:

```
sudo shutdown -r now
```

When the Pi is back up again, you'll be able to connect to the new access point and browse normally.

5 TORIFY ACCESS

Your Raspberry Pi is now fully functional as a wireless hotspot. However, the data is still not anonymised yet. So, let's get Tor added to the mix. SSH back into your Pi and then install Tor with:

```
sudo apt-get install tor
```

When it's installed, edit Tor's config file '/etc/tor/torrc' and add the following at the top:

```
Log notice file /var/log/tor/notices.log
VirtualAddrNetwork 10.192.0.0/10
AutomapHostsSuffixes .onion,.exit
AutomapHostsOnResolve 1
TransPort 9040
TransListenAddress 192.168.12.1
DNSPort 53
DNSListenAddress 192.168.12.1
```

These settings inform Tor about the IP address of our access point and asks that it anonymises any traffic that flows over it. Next up, we'll change the routing tables so that connections via the Wi-Fi adaptor (wlan0) are routed through Tor. First, flush the existing redirection and NAT rules with:

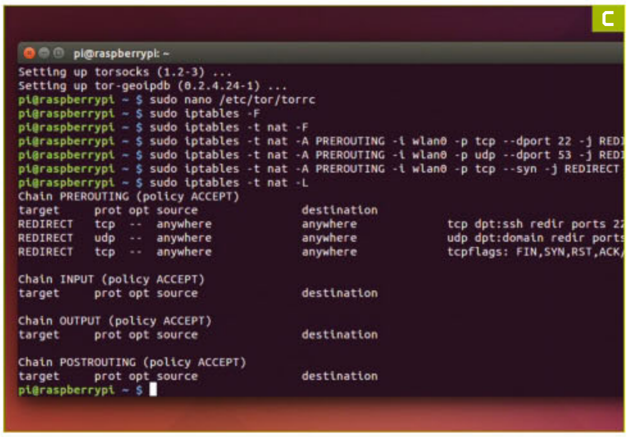
```
sudo iptables -F
```

Go on to:

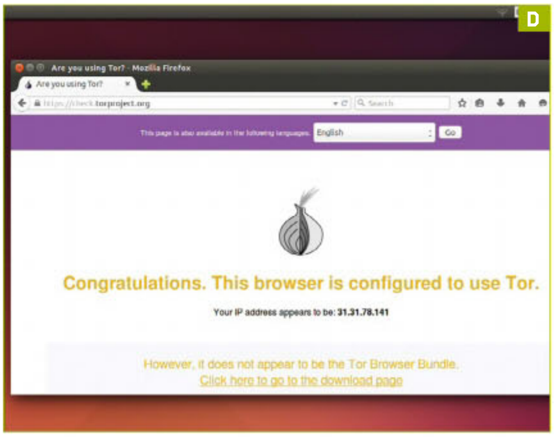
```
sudo iptables -t nat -F
```

Since we'll still want to be able to SSH into the Pi, we'll add an exception for SSH's Port 22 with:

```
sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp --dport 22 -j
REDIRECT --to-ports 22
```



```
Setting up torsocks (1.2-3) ...
Setting up tor-geoipdb (0.2.4.24-1) ...
pi@raspberrypi ~ $ sudo nano /etc/tor/torrc
pi@raspberrypi ~ $ sudo iptables -F
pi@raspberrypi ~ $ sudo iptables -t nat -F
pi@raspberrypi ~ $ sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp --dport 22 -j REDI
pi@raspberrypi ~ $ sudo iptables -t nat -A PREROUTING -i wlan0 -p udp --dport 53 -j REDI
pi@raspberrypi ~ $ sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp --syn -j REDIRECT
pi@raspberrypi ~ $ sudo iptables -t nat -L
Chain PREROUTING (policy ACCEPT)
target     prot opt source               destination
REDIRECT   tcp  --  anywhere             anywhere             tcp dpt:ssh redir ports 22
REDIRECT   udp  --  anywhere             anywhere             udp dpt:domain redir ports
REDIRECT   tcp  --  anywhere             anywhere             tcpflags: FIN,SYN,RST,ACK/

Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination

Chain POSTROUTING (policy ACCEPT)
target     prot opt source               destination
pi@raspberrypi ~ $ 
```


D
Are you using Tor? - Mozilla Firefox
Are you using Tor?
https://check.torproject.org
Search
This page is also available in the following languages:
English
Go

Congratulations. This browser is configured to use Tor.

Your IP address appears to be: 31.31.78.141

However, it does not appear to be the Tor Browser Bundle.
Click here to go to the download page

We'll now add two rules [Image C]. The first is a passthrough rule for DNS lookups. The second directs all TCP traffic to Tor's port 9040:

```
sudo iptables -t nat -A PREROUTING -i wlan0 -p udp
--dport 53
-j REDIRECT --to-ports 53
sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp
--syn -j  REDIRECT --to-ports 9040
```

Like before, these rules won't be carried on to the next session. To load them on reboot, all you have to do is save them to the NAT save file like before with:

```
sudo sh -c “iptables-save → /etc/iptables.ipv4.nat”
```

» In the previous section, we've already configured the '/etc/network/interfaces' file to load the contents of this file when the interfaces are activated. You can now enable the Tor service with:

```
sudo service tor start
```

and update the relevant boot scripts with:

```
sudo update-rc.d tor enable.
```

That's it. Now restart the Pi. When it's back up, you'll be able to connect to the Pi hotspot, TorSpot, as before. However, your traffic will now be routed through the Tor network [Image D].

» You can verify this is happening by heading to check https://torproject.org from any device that's connected to TorSpot. The page will also list your IP address, which will not be that of your ISP. You can visit this page from another device that is connected to TorSpot and it will show a different address. Congratulations, it's all done. You can now anonymously browse the internet on all of your devices. ■

ANOTHER PI TUTORIAL NEXT MONTH

TOR-IN-A-BOX OPTIONS

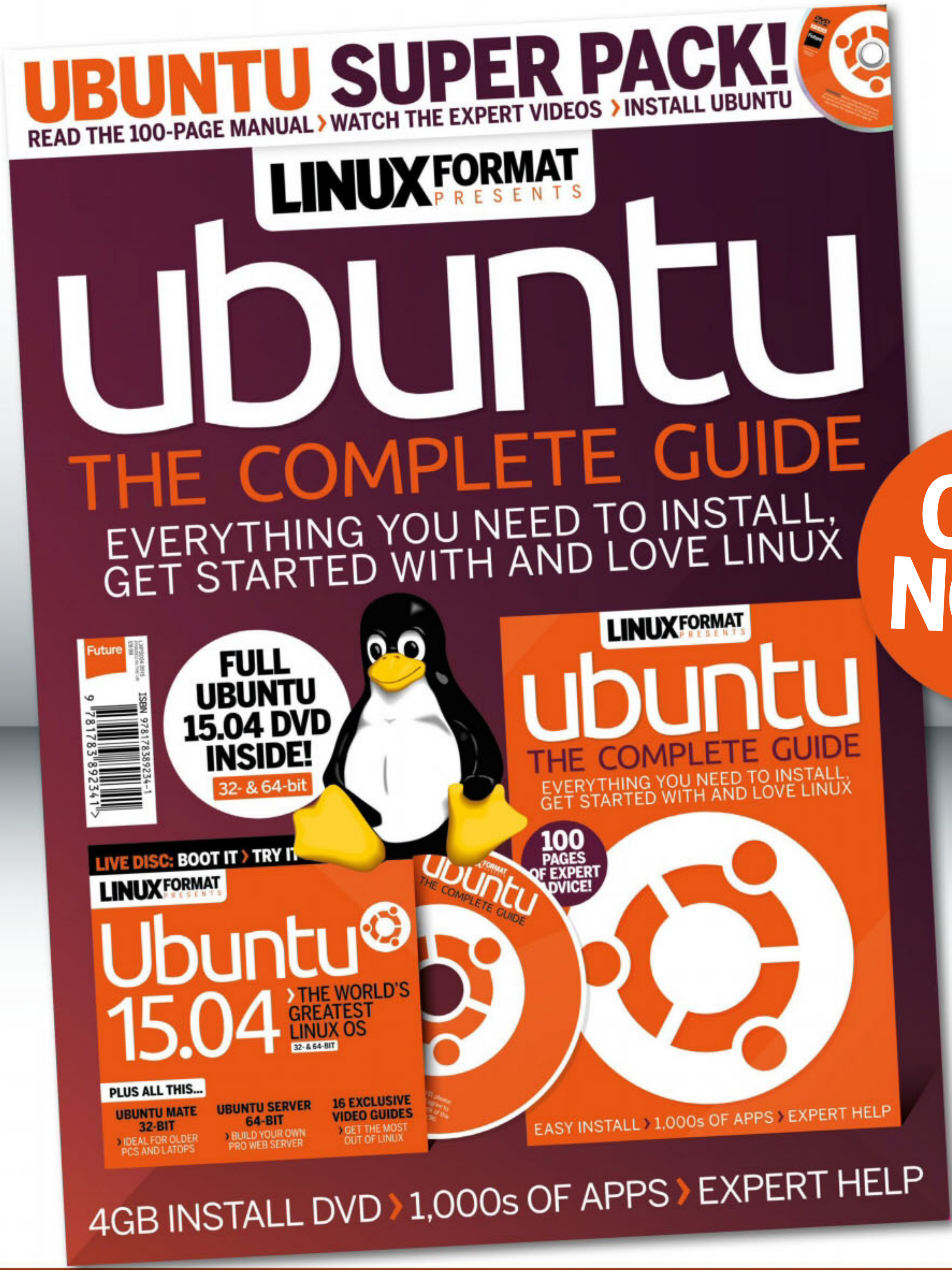
If you find this tutorial too cumbersome, or want to set up something for a non-technical friend or relative, there are several ready-made hardware solutions that can anonymise all their web traffic in a similar fashion.

There's the OnionPi Pack from AdaFruit (http://bit.ly/AdaOnionPi), which includes a Raspberry Pi B+ and a compatible USB Wi-Fi adaptor, along with a case for the Pi, cables, SD card and everything else you need to set up your Torrified Wi-Fi hotspot. The bundle costs £45. However, you'll still have to follow the instructions and set it up yourself.

If you'd rather have something more plug and play, there's the SafePlug from the guys who brought us PogoPlug. It's a £32 device that plugs into your wireless router. Once activated, it routes all traffic over the Tor network. A neater and smaller alternative is the Anonabox (www.anonabox.com). This device initially launched on Kickstarter, but after its funding was suspended it relaunched on Indiegogo. It surpassed its funding target there and began shipping in February 2015 for £64. Anonabox is a router that you can directly connect to via Wi-Fi or Ethernet.

Another router-based option is Portal, which stands for Personal Onion Router To Assure Liberty. The project produces a pre-built software image for several TP-Link routers. You can simply flash the Portal firmware image onto these routers following the instructions on the project's website (https://github.com/grugq/portal).

Enjoy software freedom
Discover Linux!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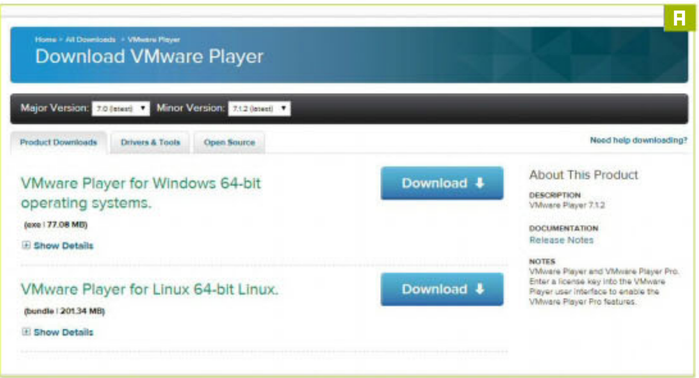
Run Windows 10 on a Virtual Machine

YOU'LL NEED THIS

WINDOWS 10
On DVD or an ISO.

VMWARE PLAYER
It's free for non-commercial use from http://vmw.re/1J8x5At.

YOU CAN'T HAVE FAILED TO NOTICE that there's a new version of Windows on the block, looking kind of cool, but mysterious and a bit frightening. If you want to take it for a test drive without jeopardising your cuddly and familiar Windows 8.1 installation, then try running it as a virtual machine. You'll need a fairly beefy PC to manage this successfully – your CPU must support virtualisation (if you're unsure, there's a utility that can tell you at www.grc.com/securable.htm) and running two operating systems at the same time will eat up RAM, so it's a good idea to have plenty. You'll get by with 4GB for each OS, but we found upping the guest OS's allocation to 8GB made things far smoother and more enjoyable. Lastly, you'll need the right kind of Windows 10 – an ISO or DVD – as the Windows 8 upgrade process replaces your Windows 8 product key with a Windows 10 one. –IAN EVENDEN


A

Download VMware Player

Major Version: 7.0 (latest) Minor Version: 7.1.2 (latest)

VMware Player for Windows 64-bit operating systems.
(exe | 77.08 MB)

VMware Player for Linux 64-bit Linux.
(bundle | 201.34 MB)

About This Product
DESCRIPTION
VMware Player 7.1.2
DOCUMENTATION
Release Notes
NOTES
VMware Player and VMware Player Pro. Enter a license key into the VMware Player user interface to enable the VMware Player Pro features.

1 PREPARE YOUR PC

While your CPU may be capable of virtualising an operating system, there's no guarantee it'll be able to do it without some tinkering. AMD chips should have AMD-V on by default, but our Asus Z77 board with an Ivy Bridge Core i7 CPU had Intel's VT-x virtualisation technology switched off, requiring a trip to the BIOS to enable it. After hitting [Del] at startup to access the BIOS, we found Intel Virtualization Technology under 'Advanced → CPU Configuration', but every motherboard will differ.

2 INSTALL VMWARE PLAYER

Save your BIOS settings and restart, then let Windows start normally. Download and install VMware Player to a drive with plenty of free space [Image A]. If you're using a Windows 10 retail DVD, pop it in the DVD drive. Otherwise, make a note of where your Windows ISO file is saved.

3 CREATE A VIRTUAL MACHINE

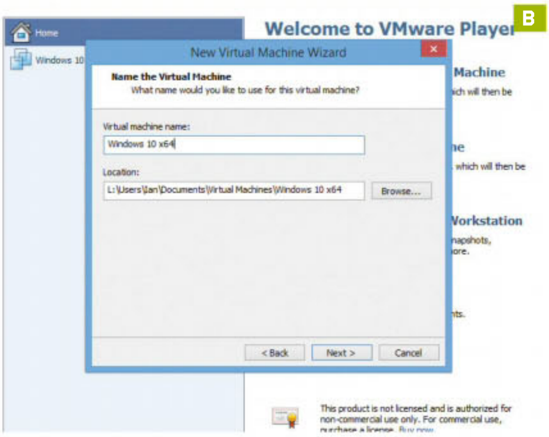
Once in VMware Player, hit 'Create a New Virtual Machine' and choose whether you're installing from an ISO or a physical DVD. It's worth noting that although this tutorial covers Windows 10, you can also use this process to test out any operating system that can be downloaded from the internet, such as Linux, if you don't have a spare PC to install it on and don't fancy dual-booting.

4 A KEY DECISION

VMware will ask for your Windows product key on the next page, and you can type it in if you like, or wait until later. We found, with a Windows 10 preview build, that putting the key in at the beginning led to an unrecoverable error later on (which we'll get to shortly). Put in your name and a password, then click 'Next'.

5 HOME FOR THE MACHINE

You'll be asked to name your new virtual PC, and find it a home on one of your hard disks [Image B]. You'll need 60GB of free space as a minimum for Windows 10, or more if you intend to use it fully and install lots of applications on it. Virtual Windows 10 starts up pretty swiftly, we discovered, even when installed on a lumbering data-dump of a spinning hard drive rather than an SSD.


B

New Virtual Machine Wizard

Name the Virtual Machine
What name would you like to use for this virtual machine?

Virtual machine name:
Windows 10 x64

Location:
L:\Users\Ian\Documents\Virtual Machines\Windows 10 x64

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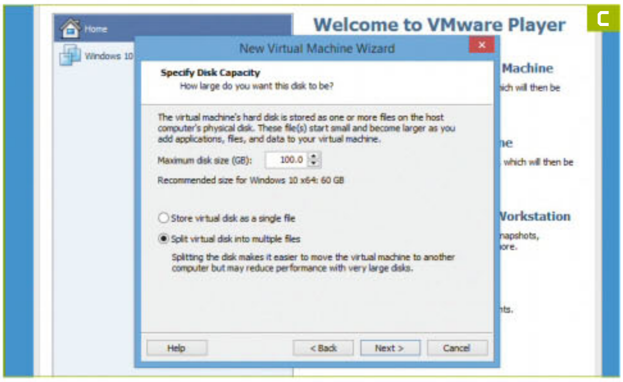
WHAT IS VIRTUALISATION?

Simply put, it's allowing one OS to run inside another, in a kind of digital Russian doll arrangement. It's something that's long been possible through software emulation, but modern CPUs (Intel since 2005, AMD since 2006) have made the process faster and easier by moving it to hardware. Virtualisation is common on servers, as it's more efficient for a powerful piece of hardware to run multiple instances of server software, all managed by a hypervisor, to do many easy tasks at once. The capability has trickled through to desktop CPUs (though some tech is still held back for server chips, such as Xeons) and allows us to pull clever tricks such as running multiple OSes at the same time.



Specify Disk Capacity
How large do you want this disk to be?

The virtual machine's hard disk is stored as one or more files on the host computer's physical disk. These file(s) start small and become larger as you add applications, files, and data to your virtual machine.

Maximum disk size (GB): 100.0

Recommended size for Windows 10 x64: 60 GB

○ Store virtual disk as a single file

● Split virtual disk into multiple files

Splitting the disk makes it easier to move the virtual machine to another computer but may reduce performance with very large disks.

6 SPACE TO THINK

There's an option to have your virtual PC stored as one or multiple files, but this only matters if you're allocating it a lot of space [Image C]. We chose the default, multiple files, and hit 'Next' to bring up a summary of the settings that will be used to create the virtual machine. VMware does a good job of choosing options, but this wouldn't be *PC Format* if we didn't want to fiddle.

7 IMPROVE THE HARDWARE

The default virtual PC is an underpowered beast. Windows 10 can run on lean hardware, but just because you *can* do something, doesn't mean you should. We tested the default settings and found it was a sluggish experience, like running Windows on a netbook. We could hear Win10 running its chipped enamel mug up and down the bars of its 2GB RAM prison. The quad-core Core i7 in our test machine is barely troubled by Win8, so we hit 'Customise Hardware' and upped the VM's CPU usage to two cores and allocated it 8GB of RAM, which speeded things up.

8 INSTALL!

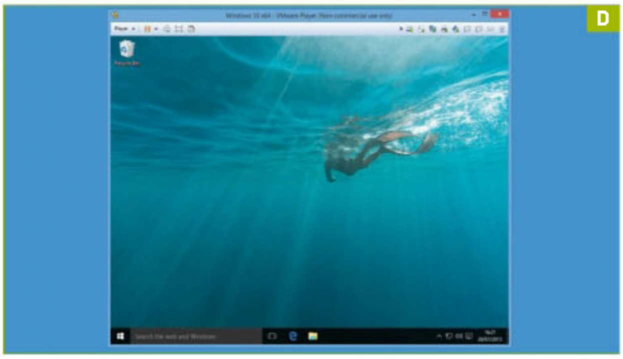
Hit 'Finish', and VMware will create your virtual machine. First, it writes the files that will house the PC to your hard drive, then it installs Windows to those files. This is the point at which, if it's going to go wrong, it will.

9 WINDOWS CANNOT READ...

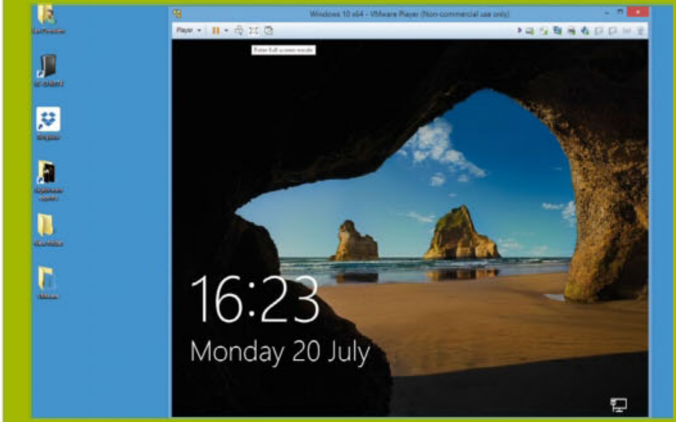
If you put your product key in at the start of the process, and Windows now claims it can't read it, there's a workaround. Go back to the beginning, and tell VMware you'll install the operating system yourself later. Set everything else the same, and you'll get a virtual PC with a blank hard drive ready to go. Before starting it, right-click the 'VM' in VMware's list, then point its DVD drive to the location of your Windows ISO or DVD. When you start the machine, the Windows install process should begin.

10 PC INSIDE A PC

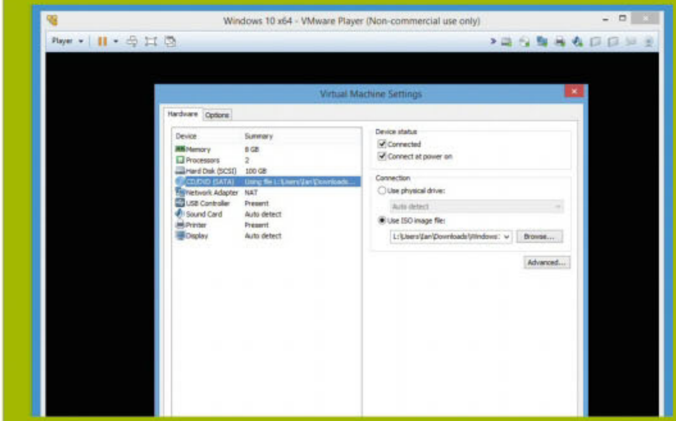
Now Windows is installed [Image D], you can select the virtual PC from VMware's menu and start it up any time you like. The virtual PC will have access to USB peripherals attached to the host machine, but can't access its hard drives outside of the space you allocated it at setup. It can't harm your host PC, so is a great chance to experiment. ■



USING VMWARE



1. HOST WITH THE MOST
The bar across the top of the screen controls how the virtual machine interacts with its host. There's a full-screen option to get rid of the borders and make the guest OS feel more 'native', which also turns the bar into a dropdown.

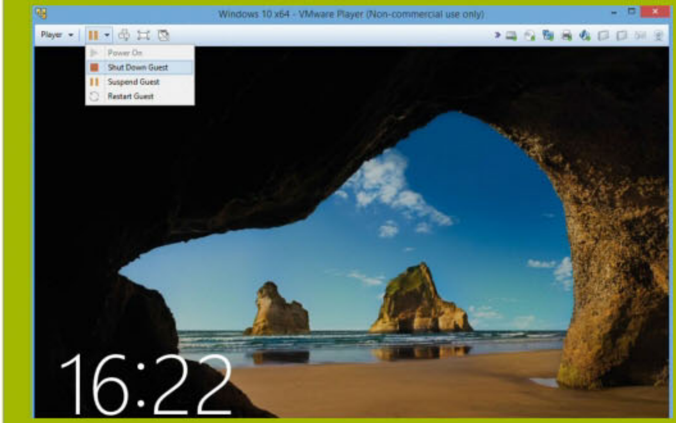


Device	Summary
Memory	8 GB
Processors	2
Hard Disk (SCSI)	100 GB
CD/DVD (SATA)	Using file L:\Users\Ian\Downloads...
Network Adapter	NAT
USB Controller	Present
Sound Card	Auto detect
Printer	Present
Display	Auto detect

Device status
☑ Connected
☑ Connect at power on

Connection
○ Use physical drive:
Auto detect
● Use ISO image file:
L:\Users\Ian\Downloads\Windows

2. ACCESS: DENIED
You can also control the guest OS's access to hardware and peripherals from the bar, loading ISO files into a virtual DVD drive or right-clicking to access the same settings menu used in setup, though many options can't be changed on a running machine.



3. LOCKDOWN
The virtual machine can also be restarted, suspended and shut off from up here. You can also [Ctrl]+[Alt]+[Del] to lock the machine or access the Task Manager. You can, of course, do all these things from within the guest operating system too.

Control your PC with Twitter

YOU'LL NEED THIS

TWEETMYPC
Download the free app from http://bit.ly/1eD8JmT.

TWITTER HAS TAKEN THE PLANET BY STORM, with people increasingly desperate to share their 140-character musings with the world. Part of its appeal is its simplicity, but underneath the hood, it's actually a complex and powerful service. This has allowed services such as TweetMyPC to create tools that are a world away from Twitter's original goals. What's great about TweetMyPC is it lets you remotely control your PC via Twitter. If you're away from home, for instance, and have left your PC on, you can use Twitter to switch it off. All you need to do is send a simple 'shutdown' command through Twitter and your PC will close your programs and shut down the PC. Or, if you've forgotten to bring a document, you can tweet 'getfile', with the name and location of the file, and your PC will email it to you. –MATT HANSON

1 SETTING UP TWEETMYPC

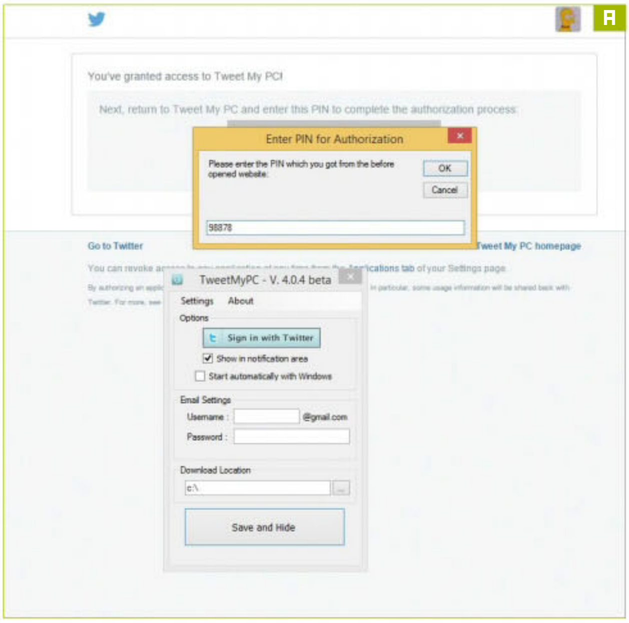
Start by downloading the TweetMyPC application, for free, from http://bit.ly/1eD8JmT. Once done, click 'Run' to begin the installation process. After installation, the configuration settings of TweetMyPC will be displayed, which will allow you to configure the program. The 'Show in notification area' box keeps an icon in the bottom-right-hand side of the screen as a reminder that TweetMyPC is running. If you want to automatically start when you load up Windows, you guessed it, check the tick box next to 'Start automatically with Windows'.

2 CONNECT TO TWITTER

For the app to work, you'll need to let it access your Twitter account. Simply click the 'Sign in with Twitter' button to begin. A window will then pop up to tell you Twitter's website will open. Click 'OK', then log into Twitter, unless you're already logged in. Note that you'll probably want to set up a new Twitter account to just use for remotely controlling your PC, otherwise your followers will see all of your commands.

3 AUTHORISE THE APP

On the page that opens, click 'Authorize app'. It says the app will 'Post Tweets for you', but it won't post anything you don't want it to – it just needs this to send the remote controls to your PC. You'll be given a PIN number to give TweetMyPC authorisation, so type this into the 'Enter PIN for Authorization' dialog box [Image A].



You've granted access to Tweet My PC!

Next, return to Tweet My PC and enter this PIN to complete the authorization process.

Enter PIN for Authorization

Please enter the PIN which you got from the before opened website:

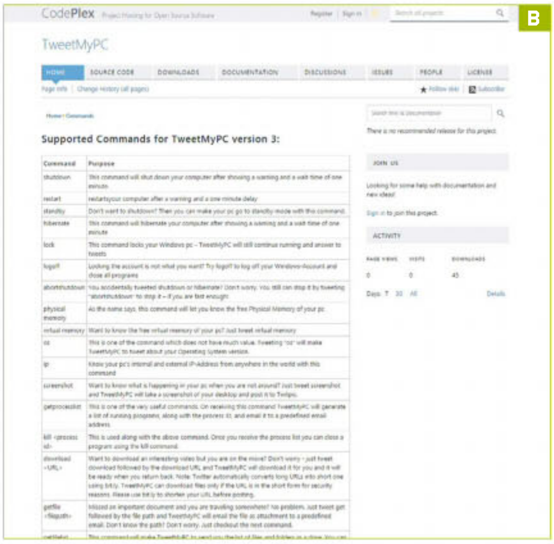
98878

TweetMyPC - V. 4.0.4 beta

☑ Show in notification area
☐ Start automatically with Windows

Email Settings
Username : @gmail.com
Password :

Download Location
c:\



Supported Commands for TweetMyPC version 3:

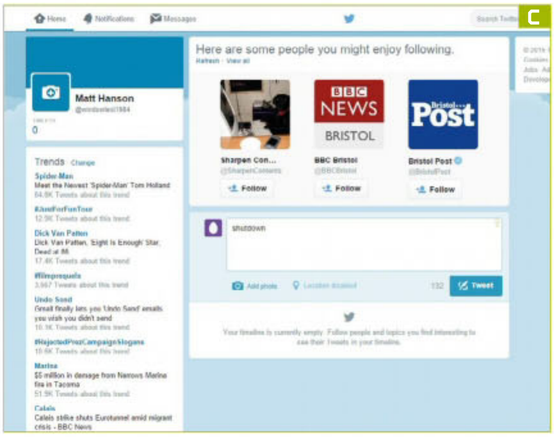
Command	Purpose
shutdown	This command will shut down your computer after showing a warning and a wait time of one minute
restart	restartsyour computer after a warning and a one minute delay
standby	Don't want to shutdown? Then you can make your pc go to standby mode with this command.
hibernate	This command will hibernate your computer after showing a warning and a wait time of one minute
lock	This command locks your Windows pc – TweetMyPC will still continue running and answer to tweets
logoff	Locking the account is not what you want? Try logoff to log off your Windows-Account and close all programs
abortshutdown	You accidentally tweeted shutdown or hibernate? Don't worry. You still can stop it by tweeting "abortshutdown" to stop it – if you are fast enough
physical memory	As the name says, this command will let you know the free Physical Memory of your pc
virtual memory	Want to know the free virtual memory of your pc? Just tweet virtual memory
os	This is one of the command which does not have much value. Tweeting "os" will make TweetMyPC to tweet about your Operating System version.
ip	Know your pc's internal and external IP-Address from anywhere in the world with this command
screenshot	Want to know what is happening in your pc when you are not around? Just tweet screenshot and TweetMyPC will take a screenshot of your desktop and post it to Twitpic.
getprocesslist	This is one of the very useful commands. On receiving this command TweetMyPC will generate a list of running programs, along with the process ID, and email it to a predefined email address
kill <process id>	This is used along with the above command. Once you receive the process list you can close a program using the kill command.
download <URL>	Want to download an interesting video but you are on the move? Don't worry – just tweet download followed by the download URL and TweetMyPC will download it for you and it will be ready when you return back. Note: Twitter automatically converts long URLs into short one using bit.ly. TweetMyPC can download files only if the URL is in the short form for security reasons. Please use bit.ly to shorten your URL before posting.
getfile <filepath>	Missed an important document and you are traveling somewhere? No problem. Just tweet get followed by the file path and TweetMyPC will email the file as attachment to a predefined email. Don't know the path? Don't worry. Just checkout the next command.

4 GET TWEETING

Click 'Save and Hide', then you can begin. To see a list of commands that you can send to your PC [Image B], right-click the icon in the notification area and select 'Edit settings'. When the window appears, click 'About', then select 'Basic Command List'.

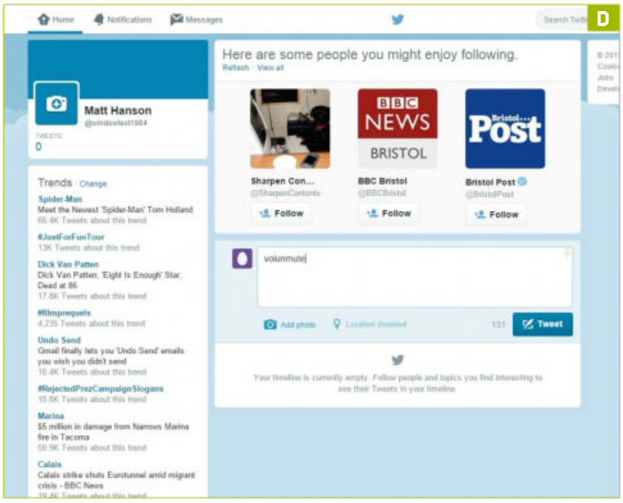
5 SHUT DOWN

Go to your Twitter homepage and in the text box type 'shutdown' [Image C]. Send the tweet, and a warning will appear on your computer saying it will shut down. It will then wait one minute, and then actually shut down. If you change your mind, tweet 'abortshutdown'.



Here are some people you might enjoy following.

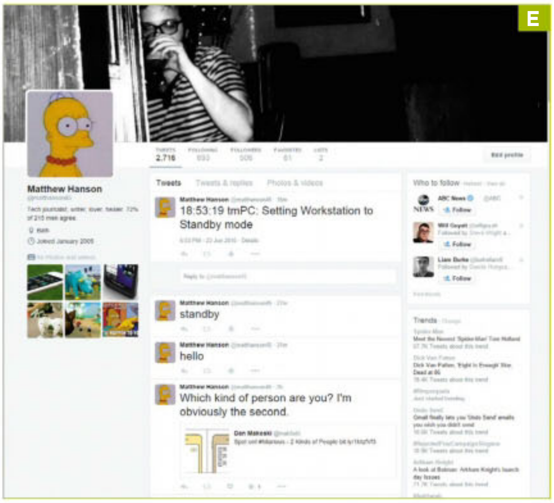
shutdown



Here are some people you might enjoy following.

volunmute

Your timeline is currently empty. Follow people and topics you find interesting to see their Tweets in your timeline.



18:53:19 tmPC: Setting Workstation to Standby mode

standby

hello

Which kind of person are you? I'm obviously the second.

6 CHANGE VOLUME

A neat use for TweetMyPC is for controlling your PC when you listen to music or watch films on it. If you want to turn down the volume without going over to your PC, just tweet ‘voldec’, and to turn it up, tweet ‘volinc’ [Image D]. To mute the volume, tweet ‘volmute’, and to unmute it, tweet ‘volunmute’.

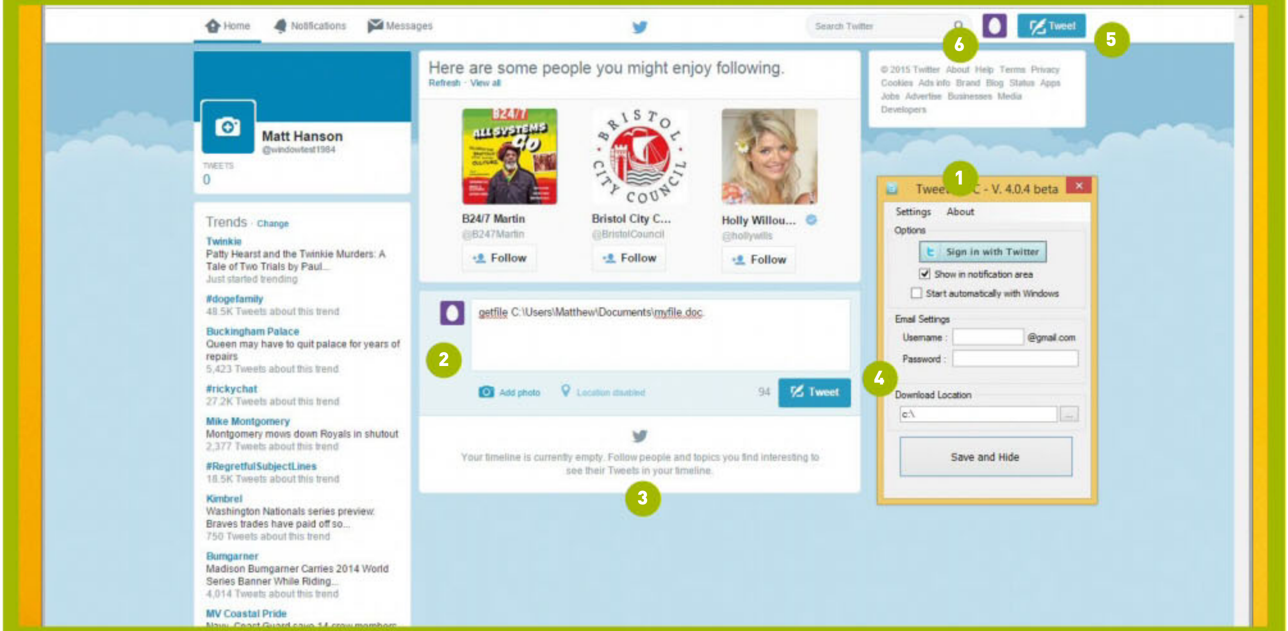
7 SEND FILES

You can also send files from your PC to your email. To do this, you’ll need to know where on your PC you saved the file. Type ‘getfilelist’ then the drive letter to get sent a list of files and their locations. You can then type ‘getfile’ and the location of your file. For example, ‘getfile C:\Users\Matthew\Documents\myfile.doc’.

8 KEEP TRACK

You now know the basic functions of TweetMyPC and can use it to remotely control your PC. It can sometimes take a while for the commands to come through, so be patient. Once a command successfully completes, you’ll get a tweet telling you what has happened [Image E]. ■

REMOTE CONTROL



Here are some people you might enjoy following.

getfile C:\Users\Matthew\Documents\myfile.doc

Your timeline is currently empty. Follow people and topics you find interesting to see their Tweets in your timeline.

TweetMyPC - V. 4.0.4 beta

Settings About

Options

Sign in with Twitter

☑ Show in notification area

☐ Start automatically with Windows

Email Settings

Username : @gmail.com

Password :

Download Location

c:\

Save and Hide

1. ABOUT
Click this menu option and select ‘Basic Command List’ to get a list of commands that you can send to your PC with TweetMyPC.

2. TWEET BOX
For the few Twitter virgins remaining, this is where you type your tweets. When using TweetMyPC, it’s also where you’ll type in the commands to send to your PC.

3. TIMELINE
This area is where you’ll see yours and other people’s tweets. This is a new account, so it’s empty. Once your PC has successfully completed a command, TweetMyPC will post here letting you know.

4. EMAIL SETTINGS
If you want your PC to email you files when you’re away from it, enter in your email settings here. It has to be a Gmail account.

5. TWEET BUTTON
Hit the blue button to tweet the command you want to send to your PC. Your PC will then receive the command and act accordingly.

6. PROFILE
This purple icon with the egg silhouette represents your Twitter profile. To change the icon to a photo or picture, select ‘Settings’. From here you can also alter your privacy settings.

ASK LUIS

BY LUIS VILLAZON

All The Stuff You Didn't Know About

Solving the insoluble and effing the ineffable since 1995

SPONTANEOUS BREAKAGE
LED BALLOON

So, the other day, I was trying to boot my Raspberry Pi 2, but a very strange thing happened. When I plugged it in, it wouldn't boot, and the lights were solid. I read online, and found out it was an SD card problem. This is funny, because it used to be fine and the SD card is the one that came with my Pi. What SD card will I need and how big should it be?

Cal Jackman

The Raspberry Pi doesn't have any firmware on the board itself. Everything that it needs to boot must be on the SD card. If it can't read that card, then all you have is an expensive LED. The red power LED is supposed to be on all the time. If it blinks even for a moment, that indicates that the voltage has dropped below the minimum 4.75V the Pi needs. If this happens during the initial boot, the process will just halt there. (Models older than the B+ don't have brownout detection circuits and the power LED just indicates that you have *some* power – you'll need to measure the voltage between TP1 and TP2 on the board to confirm that you have enough).

If the voltage is good, then your SD card has been corrupted. The card itself is probably fine, you just need to reformat it and re-download the firmware. The easiest package to use is the aptly named NOOBS, which will fit on a 4GB card. You can get it from www.raspberrypi.org/downloads.

REPRODUCIBLE CALAMITY
TIMING IS EVERYTHING

I have two monitors and one needs coaxing into working and the issue may be Windows-related. EVGA cannot help me. My primary display is an HP LP3065 linked to a high-end PC through the only DVI port on an EVGA GTX 980 SC ACX graphics card. This monitor runs at 60Hz. The secondary display is a Novatek 563D running at 75Hz. My main view is limited to the primary screen (for games, for example), and set to extended in Windows's settings.

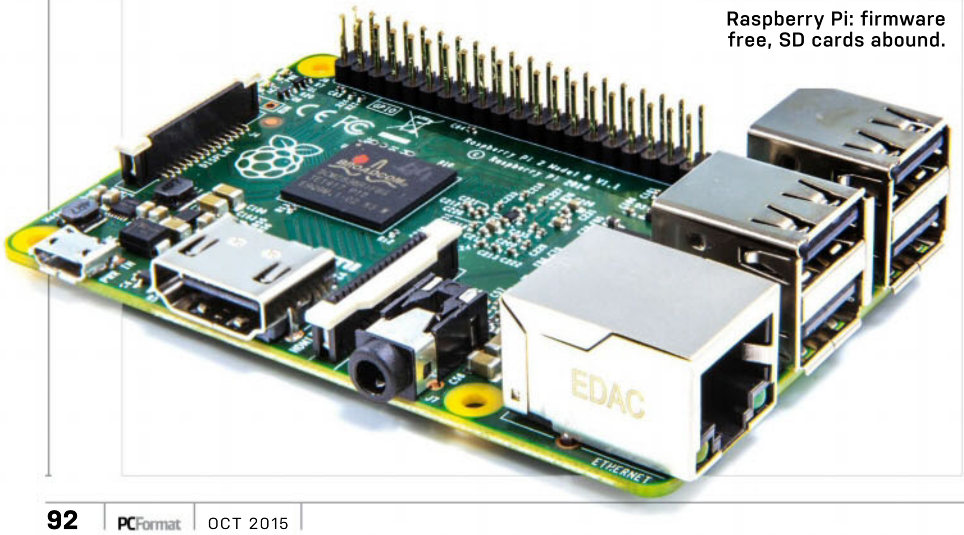
Here's the rub: the only way my secondary screen shows up is if I power it off and only switch it on manually during boot-up, specifically when POST has started counting down. If I do a conventional restart, my second screen would simply not fire up at all, unless I switch off the secondary monitor and wait for POST to take place and then switch it on – mid-POST. The second monitor is connected by way of an HDMI/RGB connector, by the way.

Albert Swanepoel

Do you mean the second monitor is using an HDMI-to-VGA adaptor? Some older monitors and TVs mislabel the VGA port as RGB, but RGB would more usually refer to component video connectors using RCA or BNC plugs.

You can't be using this because there's no way to go directly from HDMI to component video without some kind of powered converter box. We also know your monitor isn't really a Novatek 563D, because there's no such thing. Novatek make the driver electronics for LCDs, not the monitors themselves, but some older monitors still get misidentified as Novateks.

So, we know you have an old monitor on a VGA connection. I'm not really surprised this isn't autodetecting. Your graphics card will only put a signal on the VGA pins during the video detect part of the POST and if the monitor isn't actively listening on the VGA port at that point, it will assume it isn't connected to anything. If you don't want to perform this little dance every time you reboot,



Raspberry Pi: firmware free, SD cards abound.

FREE TECHNICAL SUPPORT

Email Luis for guaranteed insults and possibly even some technical help as well.

pcfhelpline@futurenet.com
PCF Helpline, Quay House,
The Ambury, Bath BA1 1UA

The six categories of all human misery

REPRODUCIBLE CALAMITY
Things that break predictably.

RANDOM WEIRDNESS
Things that break unpredictably.

CREEPING BADNESS
Things that just get worse.

OMINOUS PORTENTS
Things that might be a problem.

SPONTANEOUS BREAKAGE
Things that definitely are.

RAINBOW CHASING
Things that could be so much better.

Most monitors come with HDMI connections.

you'll need to get a monitor that supports an HDMI connection directly. Fortunately, that covers just about every monitor you can buy now.

RAINBOW CHASING

WHY DO YOU CARE?

Please answer this nagging question for me before it drives me completely nuts – why are Windows PID numbers always even? That number has to be just a random identifier, right? But if I open Task Manager in Win 8.1 and look at the Details tab, every single app has an even number in the PID column. It doesn't matter how many different apps I open – all are even!

Jarek Mansur

I don't know why this should nag you particularly. The Process ID numbers are all integers as well but you don't seem to have a problem with that. Why should it be surprising to you that of all the infinite possible numbers, PIDs discard the half that are odd numbers, but you find it perfectly normal that they discard all the non-integer real numbers. It's an infinite number of possibilities discarded in each case, but the non-integer reals are a much larger infinite set. (Yes, you can have different-sized infinities – look up Cantor's Theorem if you don't believe me.)

Anyway, process IDs aren't just even numbers, they are all divisible by four (didn't notice that, did you?). This is also true for thread IDs and kernel handles. That's because the bottom two bits are always zero, but that's really just another way of saying they are divisible by four. The ultimate reason why those bits are zero is that kernel handles reserve the bottom two bits for application developers to use them as tag bits in low-level class libraries. The rest of Windows ignores those bits and tag bits are hardly ever used, so they are almost always zero for kernel handles. Process and thread IDs don't explicitly reserve those bits for tags, but it just so happens that the same code that generates the ID numbers for kernel handles is used for processes and threads as well. So, in the case of kernel handles, the divisibility by four is guaranteed by the Windows specification, but in the case of PIDs, it's just an artefact of code reuse. Or to put it another way: it's arbitrary.

"THERE'S SO MUCH WRONG IN THIS QUESTION IT ALMOST BROKE MY WRONGOMETER."

CREEPING BADNESS

GET OFF MY WI-FI!

I don't use the internet very heavily – just some web browsing and Amazon Prime Video – so I'm quite happy with my current broadband router. The only snag is that it's quite slow. Looking at the configuration page to see if anything can be done about this, I noticed that I am using the WEP security protocol and I have read online that this is quite insecure. Could someone be hacking into my Wi-Fi to steal my bandwidth? My router doesn't support WPA/WPA2 so I'm stuck with WEP. Is there any way to improve my current security?

Richard Morten

There's so much wrong in this question it almost broke my wrongometer. Streaming video without buffering is one of the most demanding tasks for a broadband connection, so when you're watching Amazon Prime, you *are* using the internet quite heavily. But the slowness of your connection is

YOU ASKED!

FAQ

Memcomputing

What is it?

It's an alternative way to build a computer. Instead of moving data between main memory and the CPU registers, each memory unit is also its own processor. Data is stored and processed as an analogue voltage signal and all the 'memprocessors' operate simultaneously. The result is a complex waveform, with the data extracted using a frequency-shift module.

Why bother?

The claim is that it can solve NP-complete problems in polynomial time. Say you have 100 random integers. If you ask a conventional computer to find a subset that adds up to 1,875 (say), it will try every possible subset and check the result. Even at a million calculations a second, this takes years. A memcomputer architecture should take less than a second.

Would it work?

Probably not. Critics argue that memcomputers just move the exponentially hard part of the problem, from calculating the answer to actually reading it from the waveform. It's like compressing the works of Shakespeare by expressing the binary data as the ratio of two huge integers and then marking a metre-rule with a notch at this same ratio. It works in theory, but you'd need to measure the position of the notch to better than the width of an electron.

So memcomputers are perpetual motion machines?

Well, advocates claim these are engineering problems, not theoretical ones. But current implementations seem less likely to solve NP-complete problems than even quantum computers. We can't build those either, but at least no one knows why they wouldn't work.

Read more at:
arxiv.org/pdf/1411.4798.pdf

> “I CAN SEE A DAY COMING WHEN PCs WON’T BE A THING YOU CAN BUY, LIKE A HI-FI.”

dependent on your broadband tariff, not your router. Even the 11Mb/s of the 802.11b flavour of Wi-Fi ought to be enough for video streaming and that protocol dates back to 1999.

The biggest wrongness here is the idea you’re stuck with WEP. You aren’t. Yes, you’ll need to replace your router to switch to WPA2, but that’s easy. Ring your broadband provider and tell them you want a new router. They ought to be delighted to send you a modern one for free (out-of-date router hardware is as much of a headache for ISPs as it is for users). If they won’t, switch provider immediately. Use a comparison website like www.moneysupermarket.com to find one that suits you. WEP is unfixably broken. It doesn’t matter how long your password is, cracking WEP only takes a few minutes for anyone in range of your Wi-Fi signal. You could enable MAC filtering and restrict your router to only allow connections from the MAC addresses of the devices in your house, but this is quite easy to spoof too.

Probably the only way to add any useful security to a WEP router is to partially shield its antenna, so that the range doesn’t extend past the walls of your house. But that will also reduce the bandwidth for you indoors. And it’s still way worse than simply getting a modern router that supports WPA2.

RAINBOW CHASING

AUTO ADMINISTRATOR

Why does the Windows command prompt not automatically have admin privileges, even when my user account is logged in as administrator? The only time I open a command prompt is when I want to do something admin-ish and it’s really annoying to be told that I don’t have access or whatever and then have to open a new command prompt with the ‘Run as Administrator’ option. Microsoft, why you do this?

Tony Whittingham

Because it’s a security hole, that’s why. User Account Control (UAC) is designed to prevent processes from acquiring admin access without you explicitly authorising it. If you can open a command prompt with admin privileges, so can malware. If you don’t care about that at all, you can turn off UAC (search Control Panel for ‘UAC’ and drag the slider to ‘Never notify’), but I don’t recommend it.

A slightly safer option is to make a shortcut for ‘windows\system32\cmd.exe’ and put it on your desktop or somewhere. Right-click this shortcut and click ‘Properties → Shortcut → Advanced’ and tick ‘Run as administrator’. Now you can double-click this shortcut if you want to start with elevated permissions, but malware won’t be able to do the same thing without knowing what your shortcut is called.

RAINBOW CHASING

CROSS-PLATFORM SAVES

I’ve been on a bit of a retro gaming kick recently and have been playing *Final Fantasy VII* on the PSX emulator. The trouble is, I have got *too* into it and now the original version isn’t enough for me. I’d like to finish the game on the PC version of *FF*, but I don’t want to redo all the stuff I’ve completed on the PSX. Is there a way to copy my save game over to the PC version?

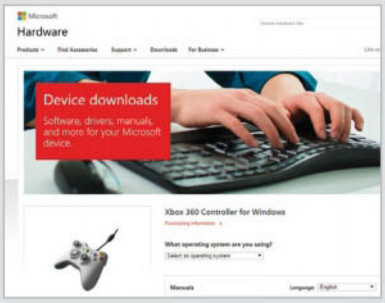
Jay Greene

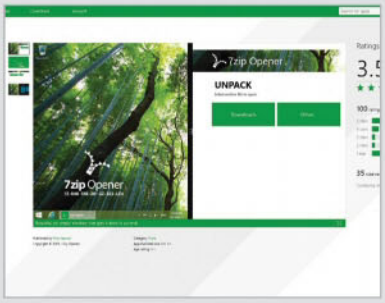
Playstation emulators save your current game in a couple of different ways. They can create a virtual memory card as a file that contains the information that the PS1 would’ve saved to its memory card. Or they can just dump the virtual memory from the emulated PS1 to a file. This lets you restore the exact state of the emulator and effectively pretend that you never stopped playing, so you can save games even at points where they don’t support explicit saving (like the middle of combat). But in either case, what you have is a binary file format that represents data structures specific to the PS1 operating system.

To port this to the PC, you’d need to write a program to parse the data out of

PS3 on PC

Repurpose your PS3 controller for PC


Microsoft
Hardware
Device downloads
Software, drivers, manuals, and more for your Microsoft device.
Xbox 360 Controller for Windows

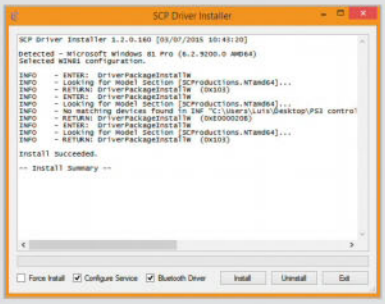


1 Plug in

Plug the PS3 controller into the PC using a USB cable. This allows Windows to detect it and install the default drivers. Now you can install the Xbox 360 driver on top of that from microsoft.com/hardware/en-us/d/xbox-360-controller-for-windows.

2 Download

To make this work with a Playstation controller, you need a wrapper for the XInput interface. The most popular one is MotionInJoy, but there’s a much better one here: http://bit.ly/1cb28eT. It’s a 7Zip, so you’ll need 7Zip Opener from the Windows App Store.



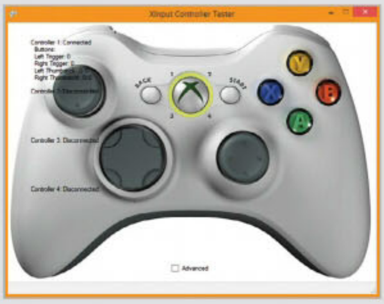
```
SCP Driver Installer 1.2.0.160 [03/07/2015 10:43:20]

Detected - Microsoft Windows 81 Pro (6.2.9200.0 AMD64)
Selected WIN81 configuration.

INFO    - ENTER:  DriverPackageInstallW
INFO    - Looking for Model Section [SCProductions.NTamd64]...
INFO    - RETURN: DriverPackageInstallW  (0x103)
INFO    - ENTER:  DriverPackageInstallW
INFO    - Looking for Model Section [SCProductions.NTamd64]...
INFO    - No matching devices found in INF "C:\Users\Luis\Desktop\PS3 contro
INFO    - RETURN: DriverPackageInstallW  (0xE0000208)
INFO    - ENTER:  DriverPackageInstallW
INFO    - Looking for Model Section [SCProductions.NTamd64]...
INFO    - RETURN: DriverPackageInstallW  (0x103)

Install Succeeded.

-- Install Summary --
```

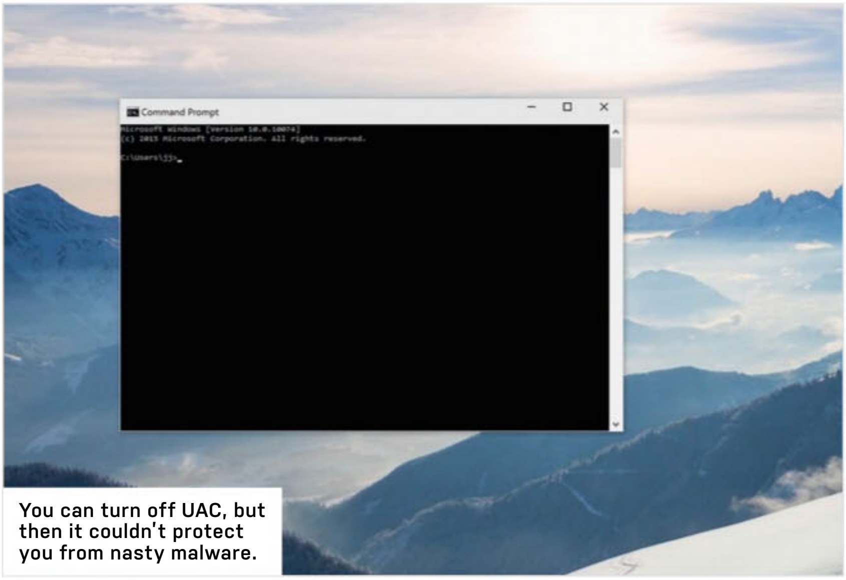


3 Install

Extract the zip file to your desktop. You can delete the Source subfolder. The files you want are in Bin. Run ScpDriver and click ‘Install’. If you want to use the PS3 controller wirelessly, you’ll need a laptop with Bluetooth, or a Bluetooth dongle. But you can also use it perfectly via USB.

4 Run

Run the ScpServer program to enable the XInput wrapper and then leave it running while you start your game. If you want to check that it’s all working fine and dandy, you can also run the SCPUser app that you’ll find in the bin/Win32 or bin/Win64 subfolders.


Command Prompt

```
Microsoft Windows [Version 10.0.10074]
(c) 2015 Microsoft Corporation. All rights reserved.

C:\Users\JJ>_
```

You can turn off UAC, but then it couldn't protect you from nasty malware.

it and write it in a format that the PC version of the game would expect. Even if you're an amazing programmer and really, really bad at *FFVII*, I'm pretty certain this would take longer than just starting the game again from scratch.

RAINBOW CHASING

IS MY PIN IN OR OUT?

Inspired by your custom control panel for *Kerbal Space Program*, I've been trying to get to grips with the Arduino for a little project of my own (hush hush for now, I may share the details with you it if all pans out). I'm fairly familiar with basic programming and I'm gradually figuring out the essentials of the Arduino itself. But I need to be able to check whether one of the digital pins is currently set for input or output, because I'm flipping it back and forth during normal operation. Is this available as a built-in function, or do I need to have my own status variable to track it? I'd rather not do that because of the risk they will drift out of sync.
Matthias Grönegen

The input/output state of each pin is held in the Arduino's data direction registers. The pins are grouped into 'ports' of 8 bits called B, C and D (not sure what happened to A). Digital pins 0 to 7 are tracked in register DDRD, 8 to 13 are in DDRB and register DDRC is for the analog input pins.

The bit corresponding to each pin is 1 if the pin is set for output and 0 if it is set for input. So you can write:

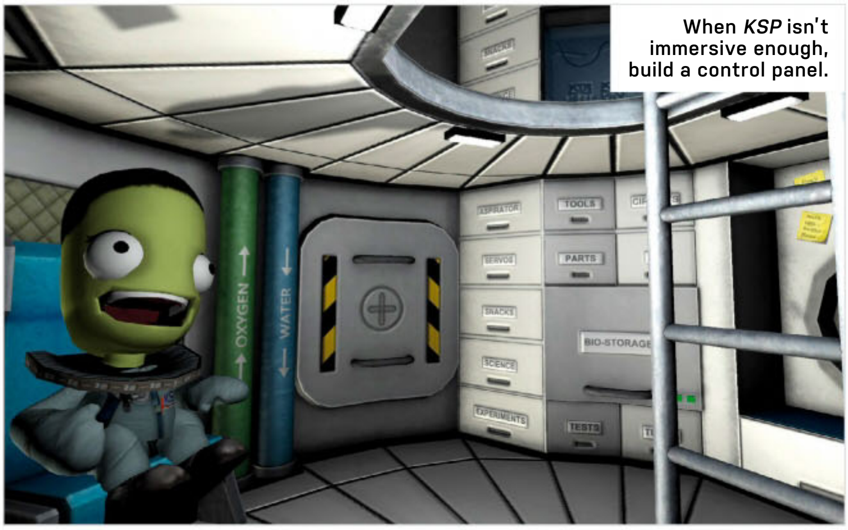
```
if ( DDRD | _BV(0) ) {
// bit 0 of register D is set
}
```

Bit 0 of DDRD is digital pin 0. You can find the full pin mappings at www.arduino.cc/en/Hacking/Atmega168Hardware.

RAINBOW CHASING

ARE DESKTOPS POINTLESS?

Is there any point to buying a desktop computer now? I can get a decent gaming laptop with an i7 processor for about £750 and it will take up a lot less space than a desktop. Apart from maybe some saving in price, is there any advantage to a desktop PC, or are they on their way out?
Jonas Mack


OXYGEN
WATER
ASPIRATOR
TOOLS
SERVOS
PARTS
SNACKS
BIO-STORAGE
SCIENCE
EXPERIMENTS
TESTS

When *KSP* isn't immersive enough, build a control panel.

FLASHBACK

What Luis Said...

PIRACY: THE TRUTH
IS DRM THE REAL PC GAMES KILLER?
FREE DVD INSIDE
GAMES, DEMOS, TOOLS 'N' APPS
PERFORMANCE GEAR & GAMING
PCFormat
EXCLUSIVE
NVIDIA
DX11
GEFORCE
GTX480
PC GAMING'S NEW DAWN
NO.1 FOR GEAR
PLUS
i5 MOBO SUPERTEST
SUPCOM 2 PRO TIPS & TRICKS
SPEAKER ROUND-UP
BOOT IN 30SECS
FREE DVD
JUST CAUSE 2
50 GREAT GAMES AND DEMOS
techradar.com
Future

5 years ago *(PCF239)*

About dual booting XP and Windows 7

I note that you have wisely avoided asking me whether I think this would be a *good idea*. By asking me if this thing is *possible*, you bind me by the laws of grammar and syntax to answer objectively. If I want to sow doubt in your mind, my only hope is that my subtle use of font will suggest an inflection to my voice. And so I say: Yes, it is *possible*.

10 years ago *(PCF178)*

About broadband speeds

I have nothing to do with the speed of the website, any more than I am consulted on the paper stock used to print the actual magazine each month. That said, the front page loads in a touch over three seconds on my 2Mb connection. I can only think of two possible reasons for your widely different experience. The first, my favourite, is that you are an idiot.

20 years ago *(PCF47)*

About RAM upgrades

You can't retrofit a second bank as this would probably involve changing other support chips on the motherboard. This doesn't mean that you can't upgrade your RAM though, it just means that you have to go up in larger (and more expensive) steps. Instead of adding another four 1MB SIMMs, you could replace your existing 1MB SIMMs with 4MB ones. This would take you to 16MB and would cost around £400.

The death of PCs? Only if you don't like upgrading, cooling, convenience, value…

Well you might as well say, "apart from going faster, what's the advantage of a car?" A desktop can be easily upgraded, runs cooler for a given clockspeed and is more convenient to use with an external keyboard and monitor. But for the middle of the performance bell curve, price is the biggest advantage of a desktop PC.

At the very bottom, a netbook is the same price as, and probably superior to, a budget desktop. And at the top end, you will always get the highest performance from a desktop PC. I don't know if that will always be true though. I can see a day coming when desktop PCs simply won't be a thing you can buy, much like no one buys a hi-fi anymore. (Kids, if you don't know what a hi-fi is, ask your dad.)

CREEPING BADNESS
LAZARUS PIXELS

Is there any truth to those dead pixel cures that appear in how-to guides on the web? I'm talking about the ones where you rub the screen with a pencil eraser or flash that area of screen rapidly using a special program? I have three pixels on my screen – two are stuck on red and the other one is dead (ie black). Is there anything that can be done about them?

Andy Marshfield

I'll be honest here: I'm not entirely sure. I have seen lots of guides that promise to fix dead or stuck pixels, but I've never seen it succeed myself and I've never been persuaded that there is a plausible mechanism either.

The least plausible are the software-only fixes. These, I'm sure, are pure snake oil. If flashing stuck pixels on and off cured them, then stuck pixels wouldn't be a thing in the first place, since flashing on and off is what pixels do in normal use. The pencil eraser technique at least offers the hope that it might schmush some of the liquid crystal into tiny gaps, but it suggests that stuck pixels are caused by air bubbles and if that was the case, you would expect them to sometimes hit several pixels at once in a blob. This doesn't happen, pixels always die in isolation, regardless of the resolution of your monitor. I also can't find any reputable scholarly source that recommends this. In fact, training manuals for IT technicians explicitly advise against this technique in case you damage the screen further.

I have a monitor with a single stuck red pixel though, so I decided to test this for myself. If I break a monitor in the interests of science, that seems like a fair price to pay. But here's the thing: when I booted that PC just now, the pixel was nowhere to be found. I tried setting the desktop background to white, black and green – it made no difference, definitely not there. So I fired up *Kerbal Space Program* because this is when I most notice it. And verily, it reappeared. So it looks as if, in my case at least, the stuck pixel is partly heat dependent. Turning the monitor off and back on again gets rid of the dead pixel for a few seconds, so does applying an ice cube to it. When it comes back, it is initially faint and flickery, becoming brighter over time. Blowing it with a hair dryer makes it brighter, quicker.

What didn't make any difference, at any temperature, was rubbing it with a pencil eraser. Or any of the other supposed cures. My hunch is that a lot of the reported successes with these techniques were really just the monitor cooling down at the same time. If any reader has genuinely managed to permanently fix a stuck pixel by rubbing it, do please write in and contradict me.

RANDOM WEIRDNESS
THE CASE FOR CASES

I'm building my own PC, which will be mainly a gaming rig for things like *Witcher 3* and *GTA V*, so I'm going for performance. I'm happy with my current list of components [long, boring list snipped], but I'm not sure what case to get. Do I actually need a case at all? The CPU and GPU have their own fans already, so surely I'll get better cooling just by leaving the case out altogether?

Dane Harris

Absolutely. Even a really good case will always interfere with cooling a little bit – that's why a good first diagnostic test for an overheating PC is to try running it with the case off and see if that helps. The case is mainly a convenient place to hang the power button and a way of keeping the cat from jumping on the motherboard. I have an old laptop that I dismantled and mounted on a piece of driftwood on the wall – all the daughter boards are connected with long ribbon cables and it all still boots.

If you like the industrial aesthetic, a caseless PC is perfectly feasible and it makes it easier to keep an eye on the dust build up. You'll need to mount it on a shelf out of the way though. ■

STATS KNOW-IT-ALL?

Quiz

1. Which of these does the Edge browser *not* support?
a) Flash
b) ActiveX
c) HTML 4
d) All of them

2. Which of these *does* Edge support?
a) DASH
b) MSE
c) EME
d) All of them

3. What is CENC?
a) Common ENCryption
b) CErtified Network Cryptography
c) Cryptography ENgineered Certificates
d) Complete Encryption for Native Computing

4. How many lines of code were removed from IE to make Edge?
a) 220
b) 2,200
c) 22,000
d) 220,000

5. How many new features are in Edge?
a) None, just security fixes
b) 18
c) 49
d) 811

Answers: 1b 2d 3a 4d 5c

Future

YOUR FAVOURITE MAGAZINE!

PC Format
PERFORMANCE GEAR & GAMING
BEST GPUs FROM £169-£830
FULL HD GAMING PC FOR £466

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Month in numbers…

1.4 million

The number of Chrysler vehicles recalled in the US due a software vulnerability allowing uConnect-equipped cars to be hacked and remotely driven. Google reveals it won't be commissioning Fiat Chrysler to build its self-driving cars.

1,000

Tech experts, including Stephen Hawking, Steve Wozniak and Elon Musk, signed a letter warning against developing weapons with AI, due to the potential for creating crazed killer robots. John Connor was unavailable for comment.

400ft

The maximum permitted height in the US that Amazon Prime Air courier drones could fly. Amazon's proposals suggest superhighways between 200ft and 400ft for long-distance, collision-detecting traffic.

24,000

The diameter, in pixels, of a wraparound 3D VR image filmed by NextVR's stereoscopic cameras. Think of Oculus Rift, but displaying a real wraparound view of a live sporting event or even a movie. We're waging it'll penetrate one genre very well.

3,000

The sound wattage output of the Devialet Phantom Silver speaker system. Supposedly producing the most perfect sound quality in the world, it incorporates a highly pressurised spherical cabinet design to mimic larger speakers.

THE VOICE OF REASON

Radeon, And On

PC Format has a mole. A man wedged inside the games industry's nether regions. A man rendered so hideously paranoid by a life spent playing sub-standard PS2 ports that he won't even let us edit his copy. These are his troubled thoughts…

GIVE IT A DECADE and even a Titan X will be worth less than a Greek pension plan, leaving you to flog it for a fiver on eBay or consign it to a slow death, rotting alongside apple cores and used condoms. If it's lucky, this once-worshipped piece of tech porn may make it to lands less fortunate and be stripped down to its component parts by a child workforce better suited to appearing in an NSPCC advert. But estimates suggest there's only a 25 per cent chance of that happening. So given the somewhat depressing state of electronic waste-recycling rates and also our lack of love for geriatric graphics cards, I'm glad AMD is here to help restore my faith that at least one hardware manufacturer has some environmental awareness.

See, where Nvidia has a habit of irresponsibly releasing a new and improved GPU range once every year to 18 months, edging the previous generations ever closer to oblivion, AMD is greener than the green team could ever hope to be. It manages to fully recycle graphics cards with next to no wastage, and can even do so twice over. It really is an incredible feat of engineering, which if nothing else, shows that those lazy child recyclers need to up their game.

The secret to AMD's respectable green credentials is so simple I'm surprised it's passed Nvidia by. Why replace a graphics card when you can just change its name? The tactic is more commonly known as 'doing a Puff Daddy', and isn't to be confused with directly peddling tech that's long past it's sell-by date, aka iPhone 5c.

AMD's most impressive example of this is the Radeon HD 7850, released in March 2012. When the time came for a new upper entry-level GPU a couple of years later, AMD saved the Earth's resources, printed some Radeon R7 265 stickers – on recycled paper, naturally – slapped on some extra memory and gave the marketing department a raise. Fast forward to June 2015 when another refresh was in order, repeat the process with Radeon R7 370 labels and hey presto, a new card, albeit one with more layers of stickers than a supermarket produce aisle at closing time. What's more, this admirable environmental responsibility isn't confined to low-end cards, as the R9 380 and 390 haven't escaped the 'make do and mend' business model, either.

However, even AMD's finely honed eco-practices have room for improvement. Some say such ageing design architectures are inefficient and too power-hungry, but I'd bet that rebranding, instead of raiding Mother Nature's resources to develop new hardware, more than cancels out any extra wattage requirements.

No, the real problem is the all-new Radeon Fury and its cutting-edge High Bandwidth Memory, which sticks out in AMD's otherwise-recycled range like a cooling tower in a windfarm. But every cloud has a silver lining. At least when the Fury X is inevitably cast onto the scrapheap, its water cooling will help it rust in peace. ■

ILLUSTRATION: KEVIN FEBRUARY

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